The Future of U.S. Shale and the Role of the Independent*

Scott W. Tinker[1]

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Roles for the Independent

- Evaluate low-cost, targeted operations in existing shale gas plays.
- Consider shallow-water offshore lease acquisition opportunities.
- Pioneer development of other organic-rich, tight rock plays (e.g., limestone).
- Develop international opportunities in lower political risk countries.
- Be the bridge between local, state, and federal regulators and policy makers.

Larger Trends

- The scale of energy demand is enormous.
- Oil and gas are a part of the future energy mix, and shale will play a growing role.
- Above-ground challenges are real, and rigorous operational practices are key.
- Energy security—affordable, available, reliable, sustainable—will drive the future energy mix.

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IPAA Annual Meeting

Dana Point, CA

June 2013

The Future of U.S. Shale & the Role of the Independent

Scott W. Tinker

Bureau of Economic Geology

Jackson School of Geosciences, The University of Texas at Austin

Outline

- A Look Back
- The US Energy Mix
- The Global Energy Mix
- Forward Steps

IPAA

Austin, Texas October 2004

The Future is Unconventional

Impact on Independent Producers

Scott W. Tinker

Bureau of Economic Geology

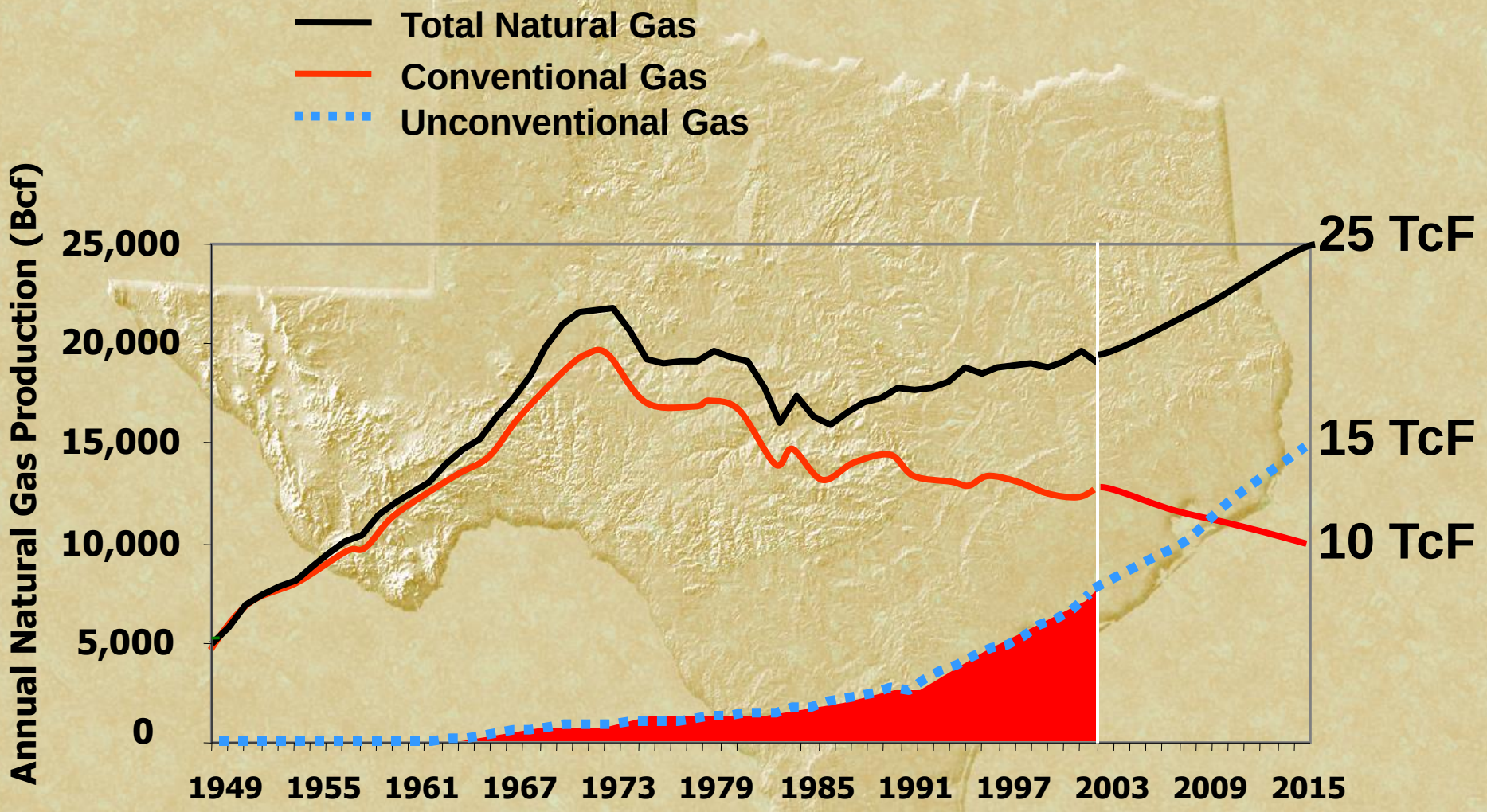
Jackson School of Geosciences

Summary (2004)

Impact on Independent Producers

- Fossil energy will play a critical role in global energy demand for the next half century.
- We are within sight of a natural gas economy.
- US natural gas supply is critical. Unconventional gas and LNG are coming, and vital.
- Research and technology investment is important. The Federal government has a role to play. Speak up!
- Government energy policies should be made around resource and reserve estimates, ***not*** annual forecasts.
- The future is bright, and independent producers will be key players.

US Natural Gas
(2004 forecast)



EIA (1949-1990) and NPC (1991-2015)

IPAA Annual Meeting

October 2005

Independents Must Think Unconventionally

Scott W. Tinker

Bureau of Economic Geology

Jackson School of Geosciences

The University of Texas at Austin

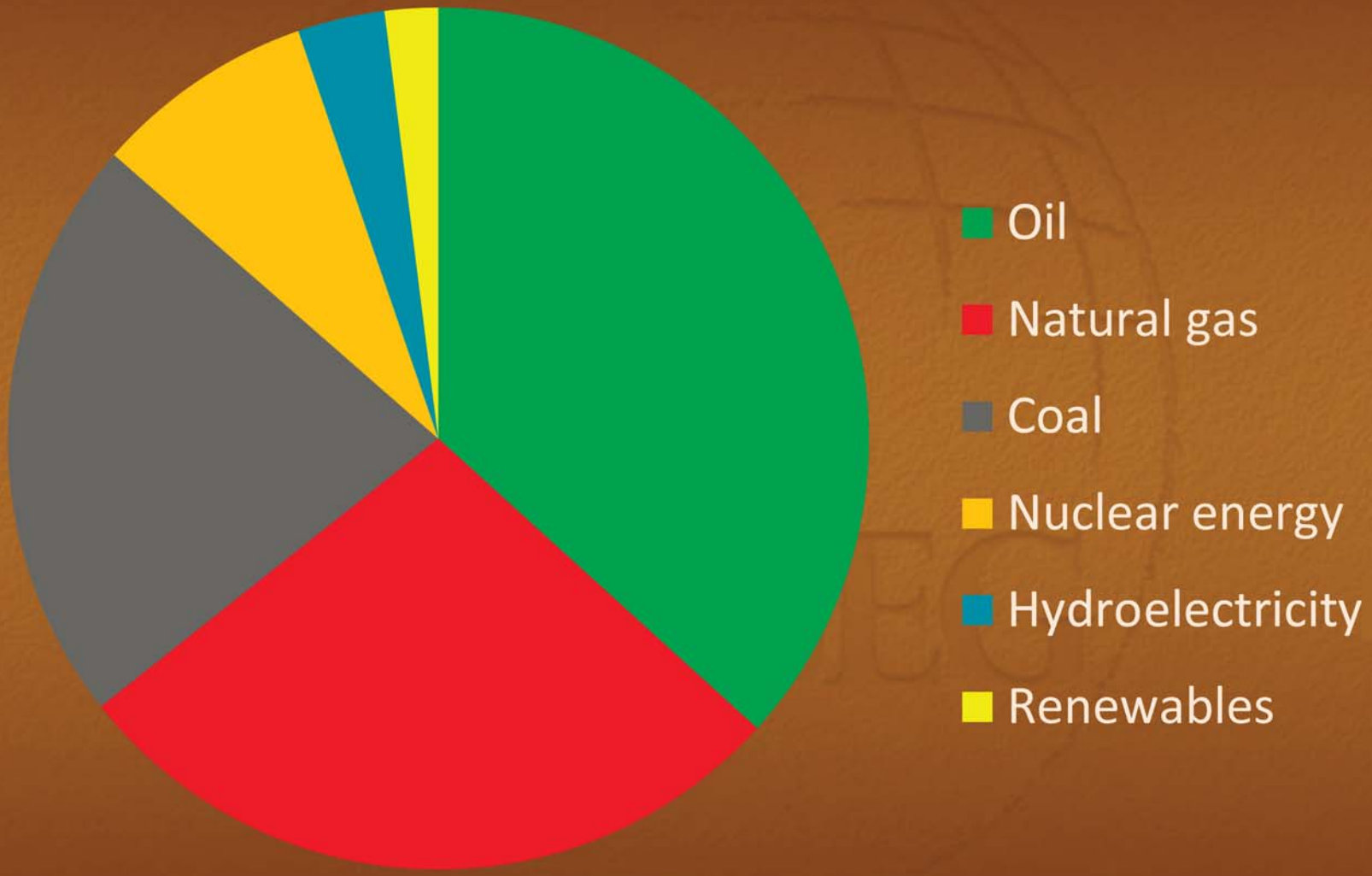
Summary (2005)

- Global demand for fossil fuels remains high
- Independent producers have a key role to play
- Tomorrow's opportunities are visible today, if you think unconventionally

The Future of U.S. Shale & the Role of the Independent

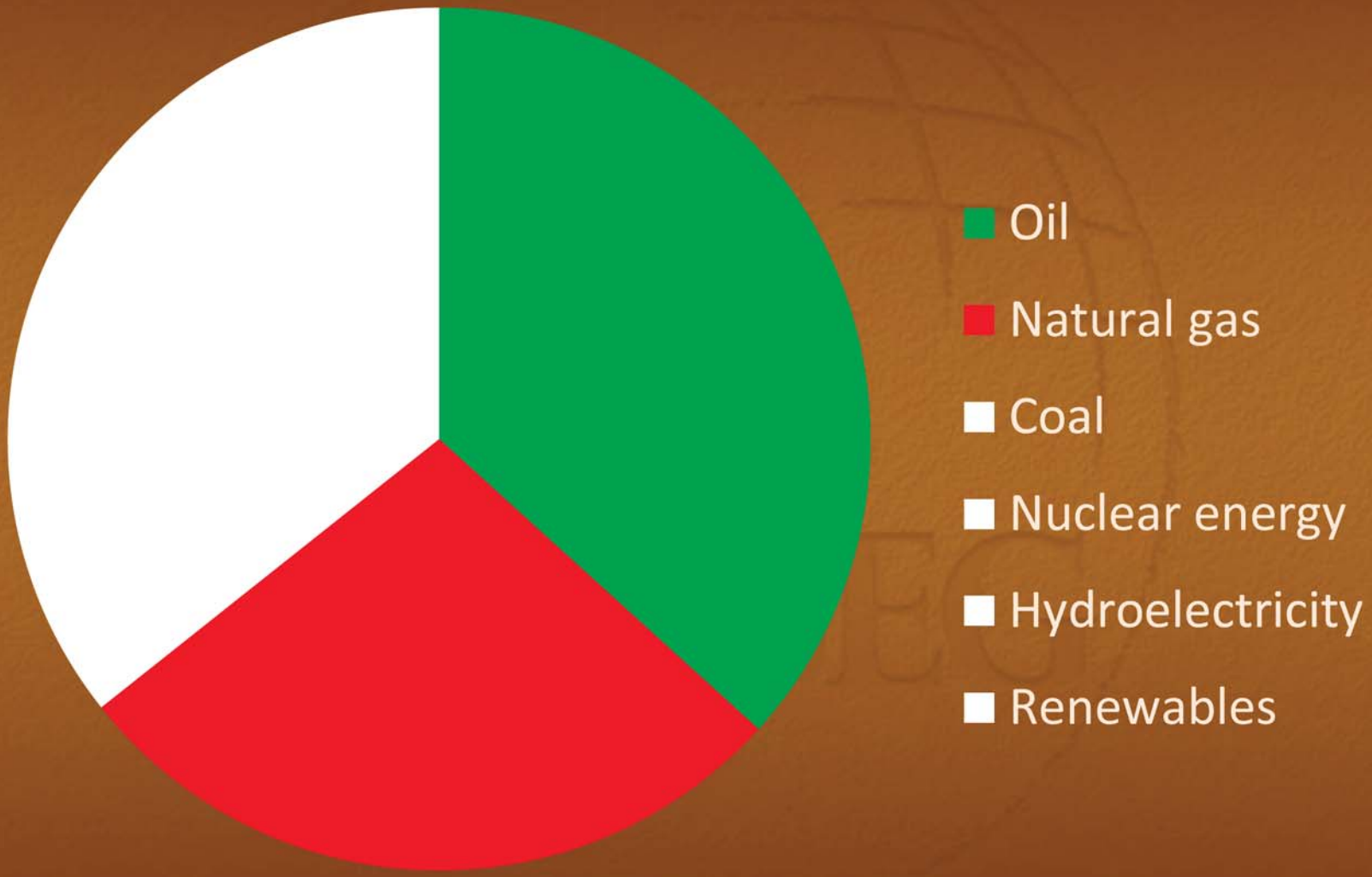
- A Look Back
- **The US Energy Mix**
- The Global Energy Mix
- Forward Steps

U.S. Energy Mix (%)



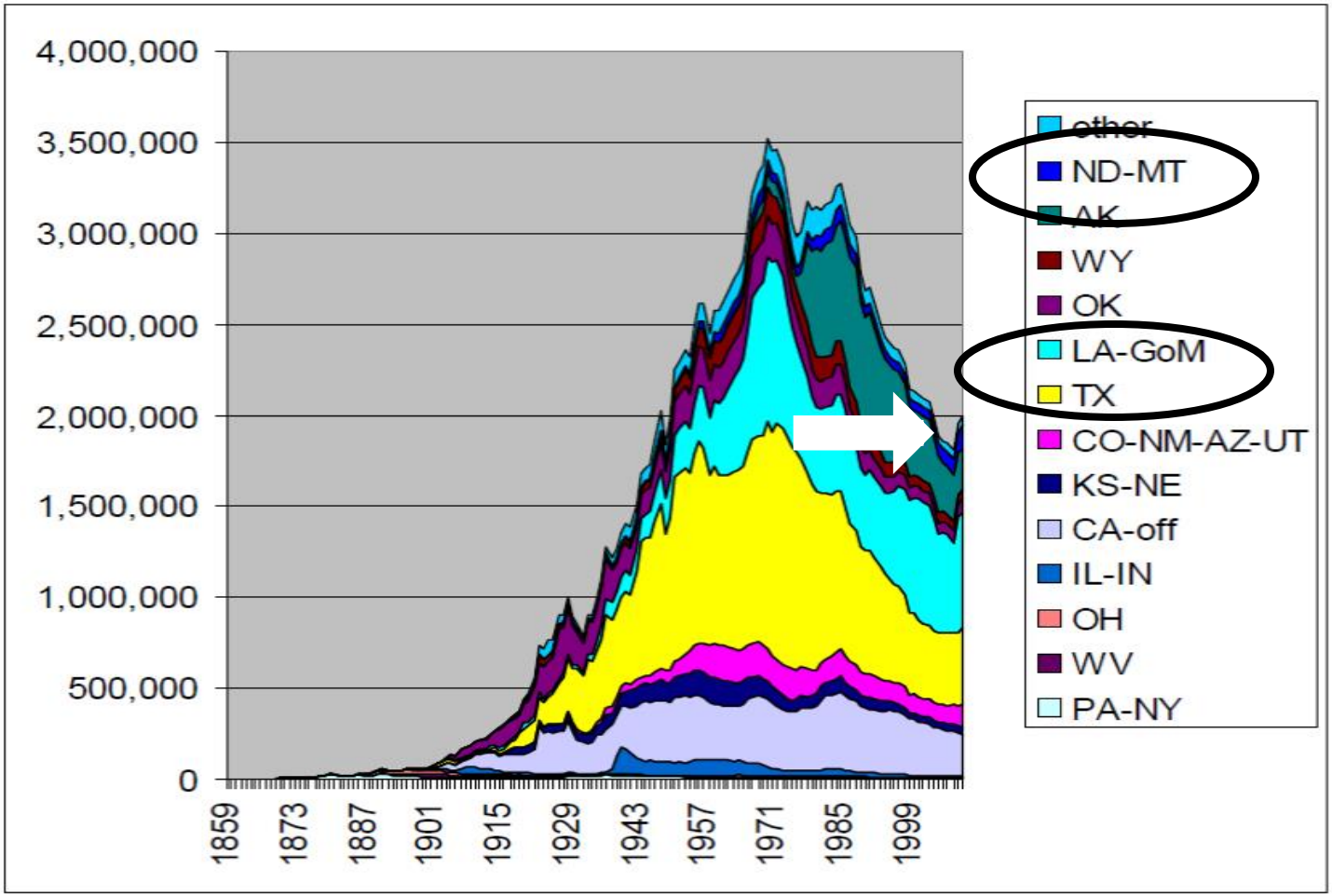
Source: EIA, 2012

U.S. Energy Mix (%)



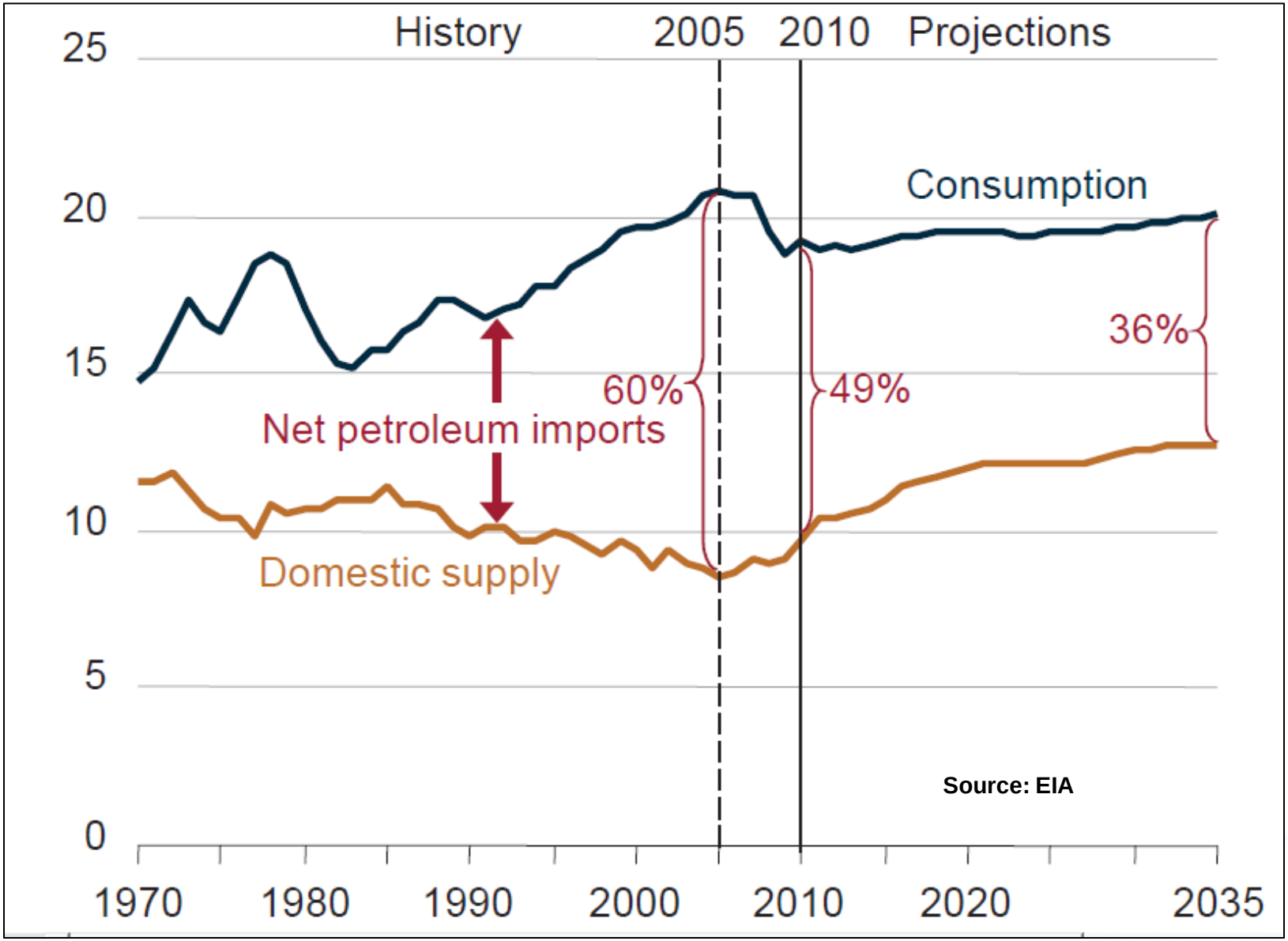
Source: EIA, 2012

Annual US Oil Production

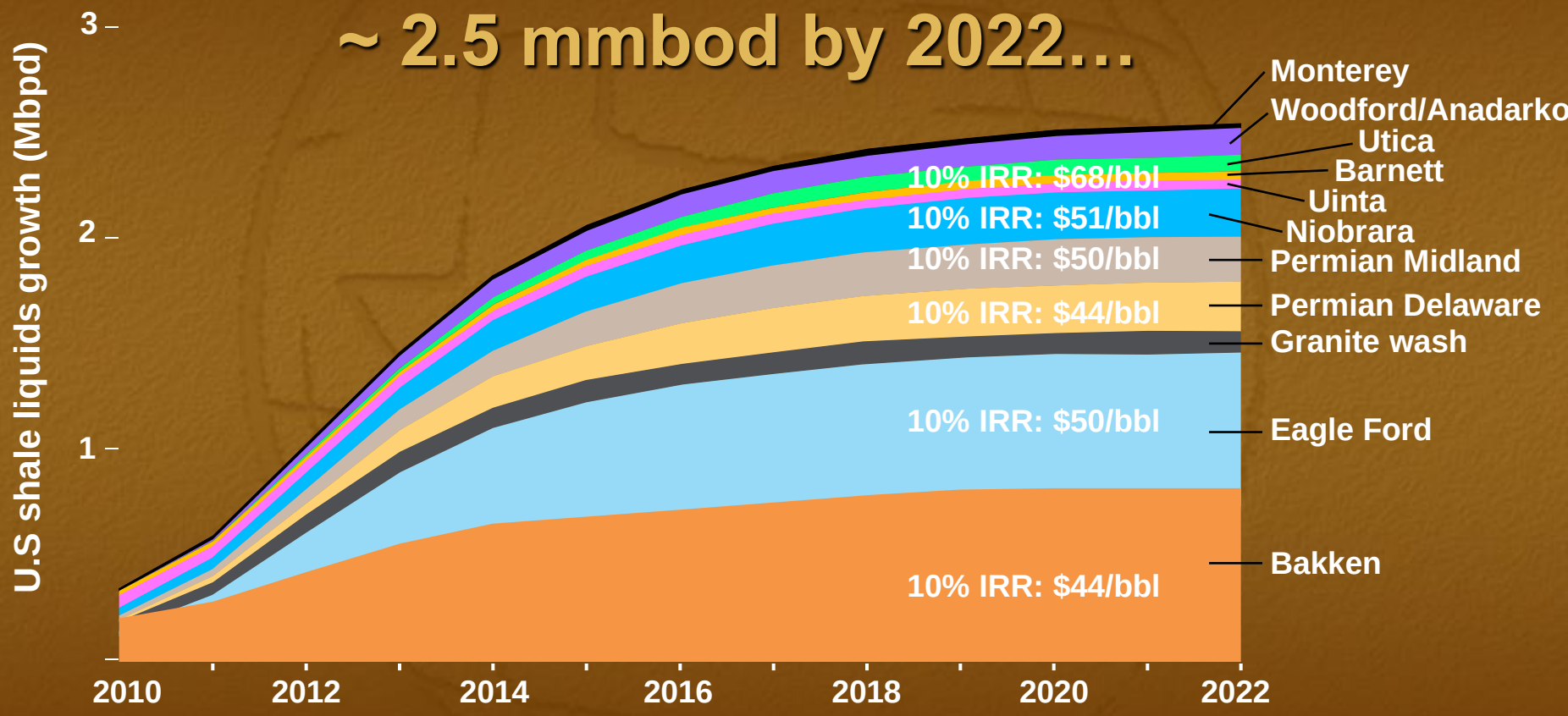


From: James D. Hamilton, Working Paper 17759, NATIONAL BUREAU OF ECONOMIC RESEARCH, 2012

Annual US Oil Production



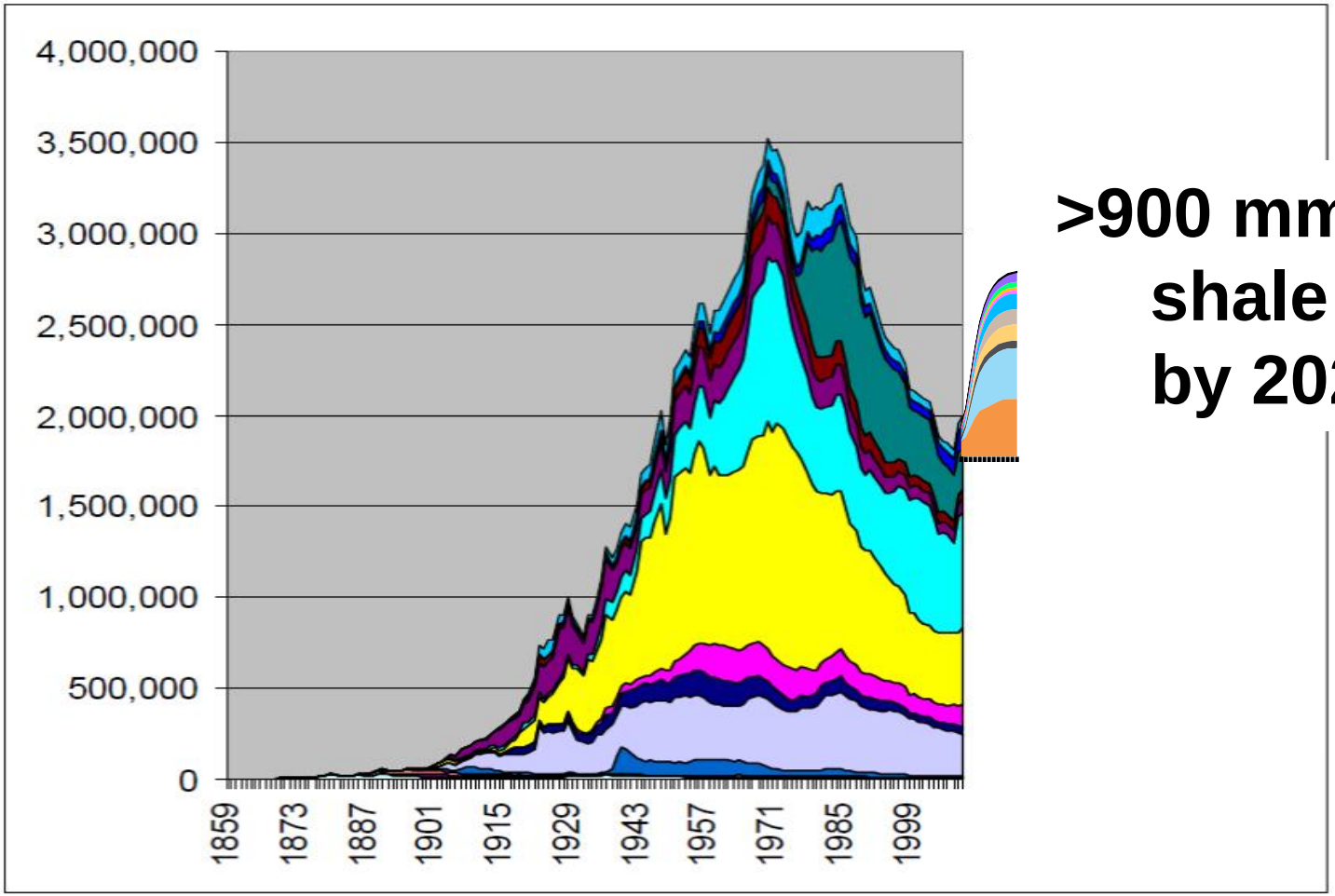
U.S. SHALE LIQUIDS PROJECTIONS



Modified after Morse et. al., 2012, Energy 2020: North America, the new Middle East: Citi GPS: Global Perspectives & Solutions, figure 14, p. 17.

IRR Source: Rystad Energy

Annual US Oil Production



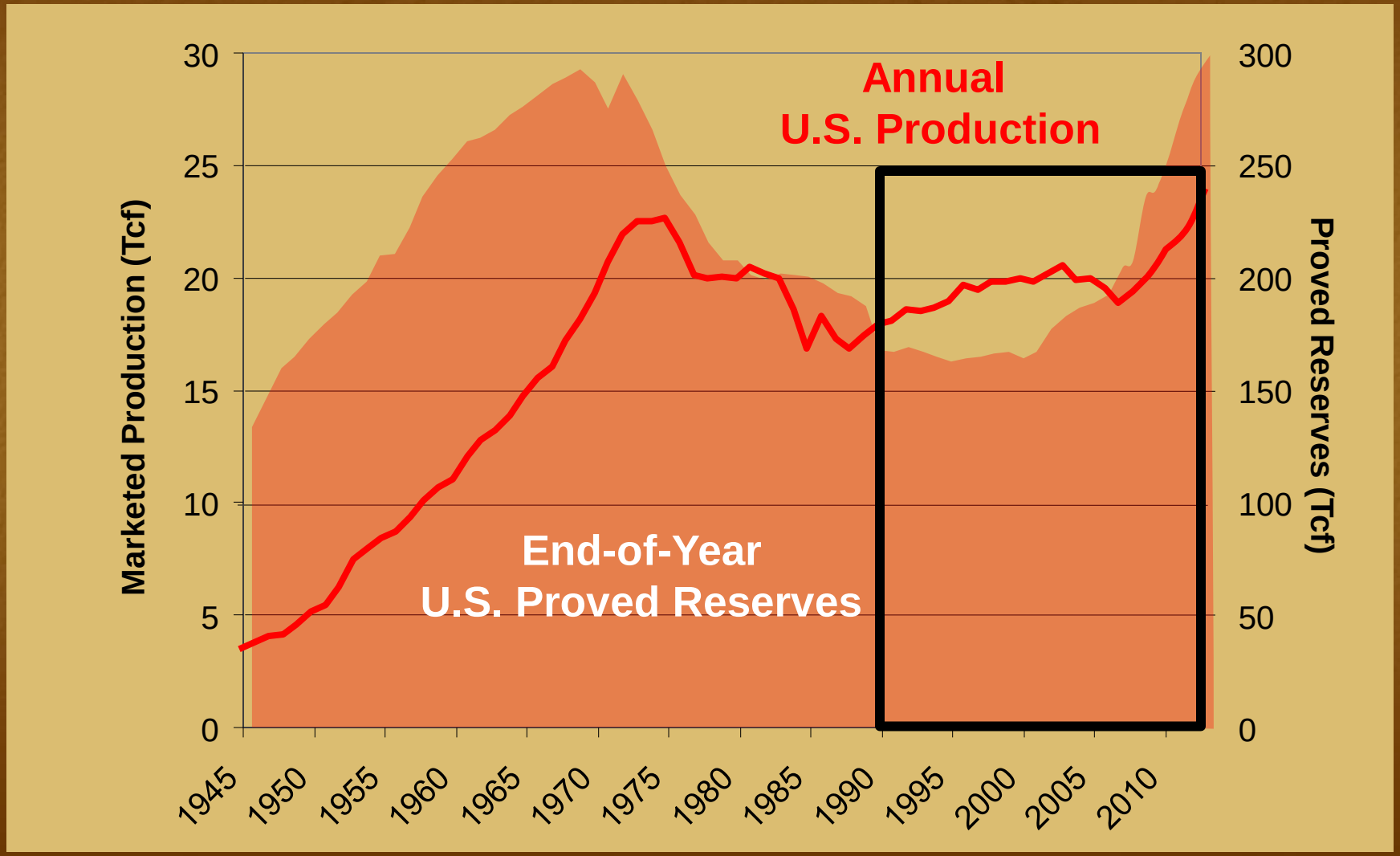
>900 mmbo/yr shale oil by 2022!

From: James D. Hamilton, Working Paper 17759, NATIONAL BUREAU OF ECONOMIC RESEARCH, 2012

Tinker, 2013

U.S. Natural Gas

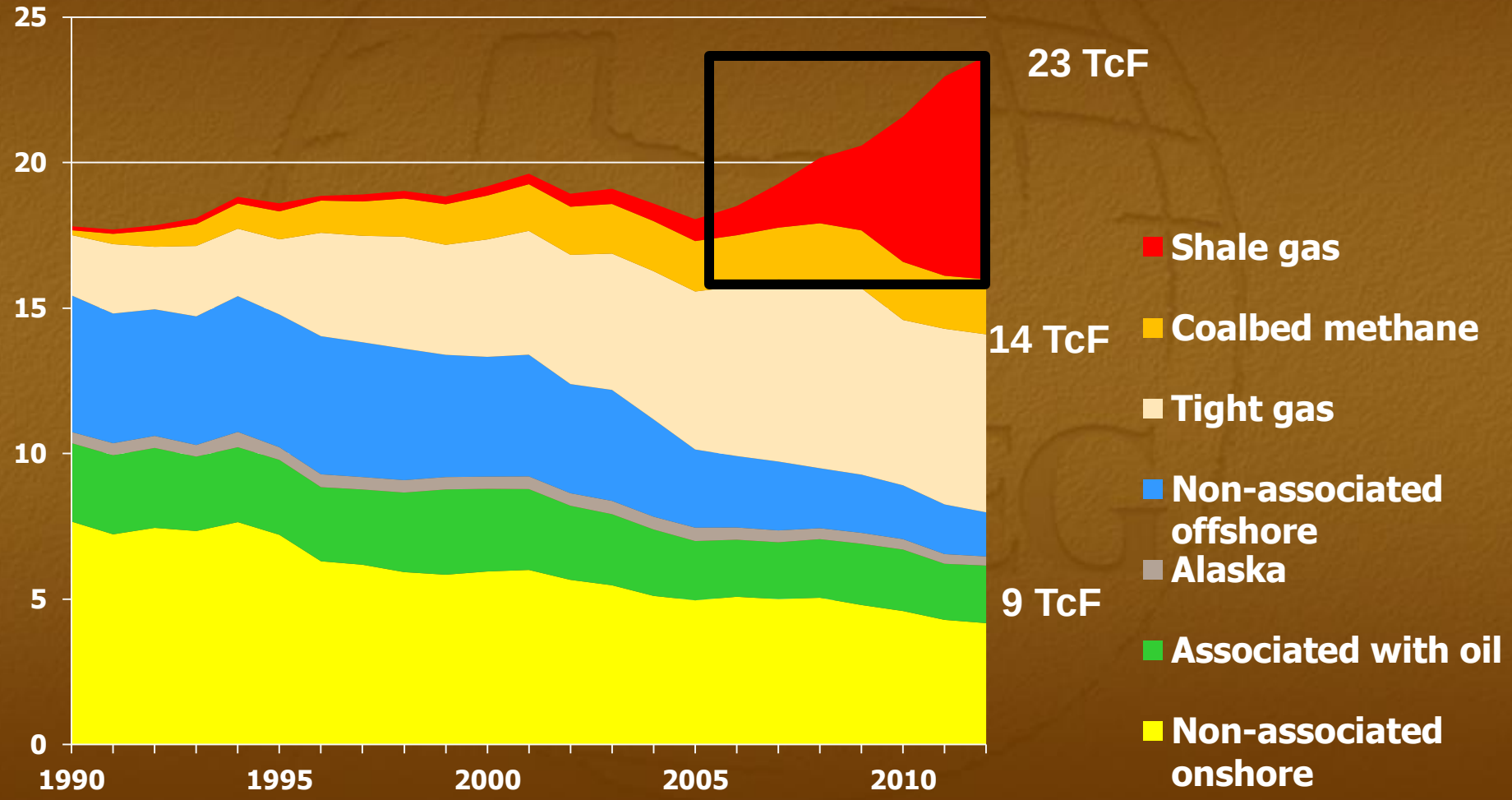
Production and Reserves



Data: BP World Energy 2012

U.S. Natural Gas

Production (TcF)



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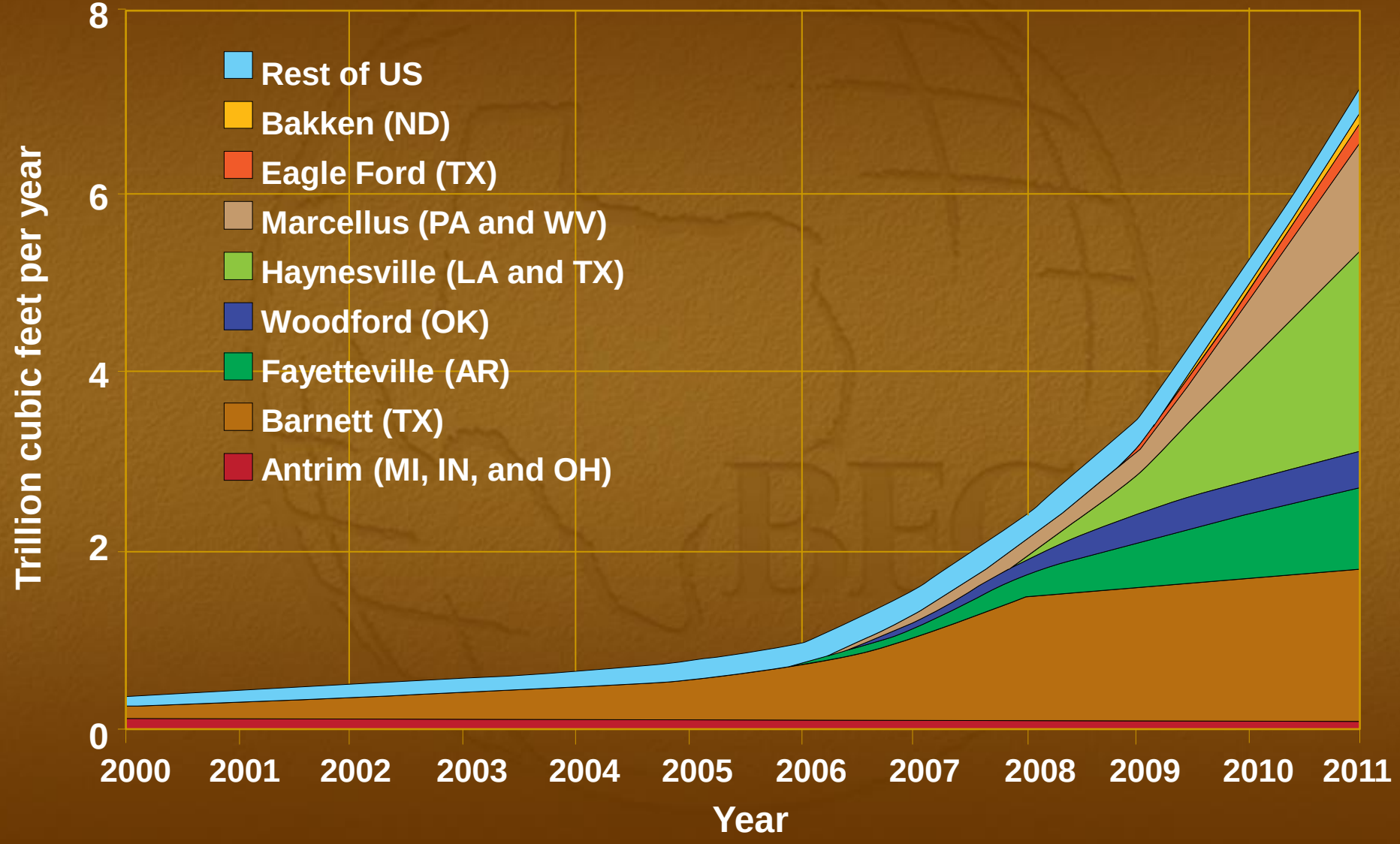
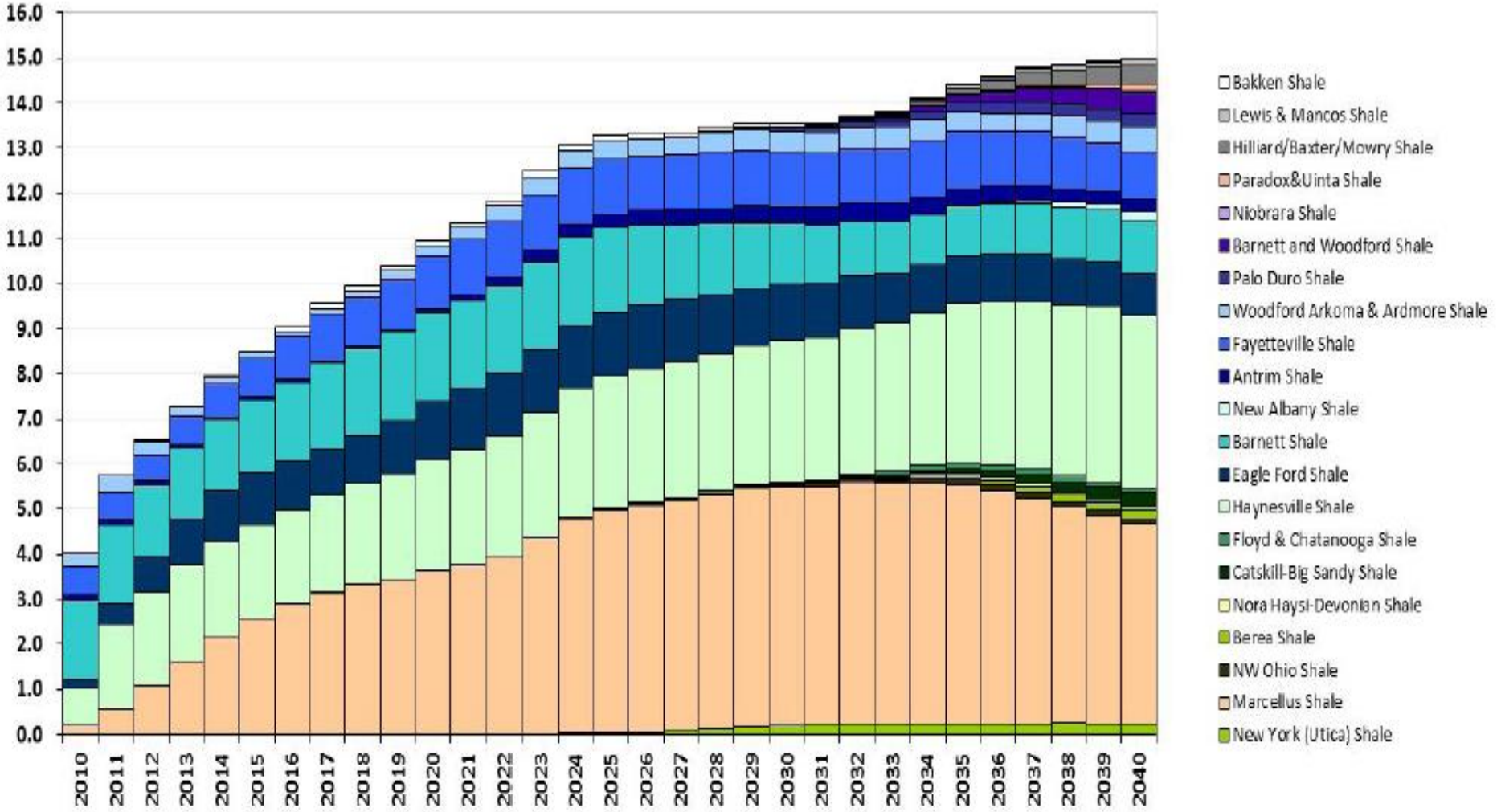
Estimated annual U.S. Dry Shale Natural Gas Production, 2000-2011



Source: US EIA

Estimated annual U.S. Dry Shale Natural Gas Production, 2000-2011

tcf **Model: Rice University, Medlock, 2012**



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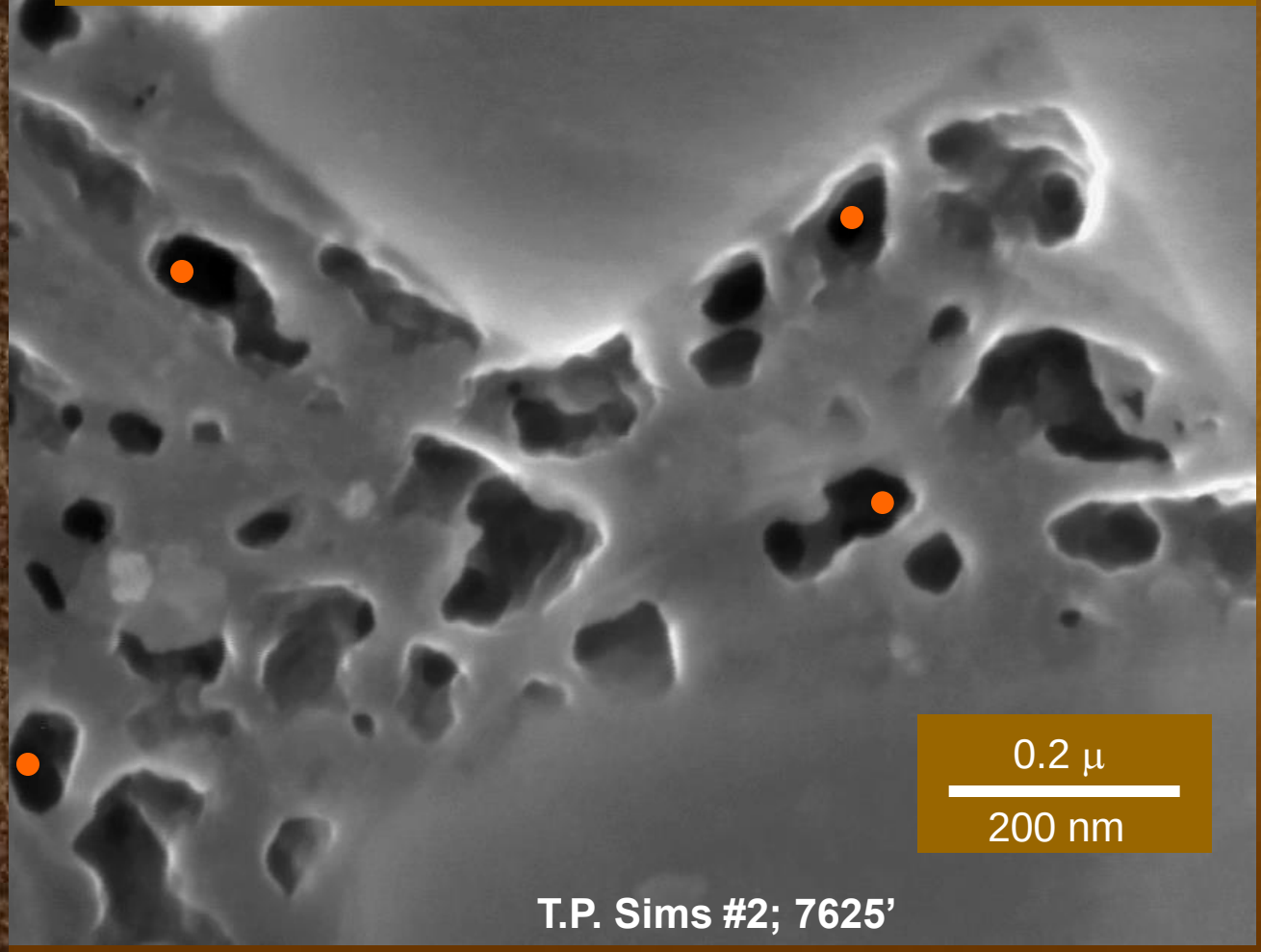
Unconventional Reservoirs

Easy to find, expensive to produce

Human Hair

50 µm

Orange dots are 20 nm in diameter



After Reed, BEG

Hydraulic Fracturing
"Fracking"

Water (~88%)

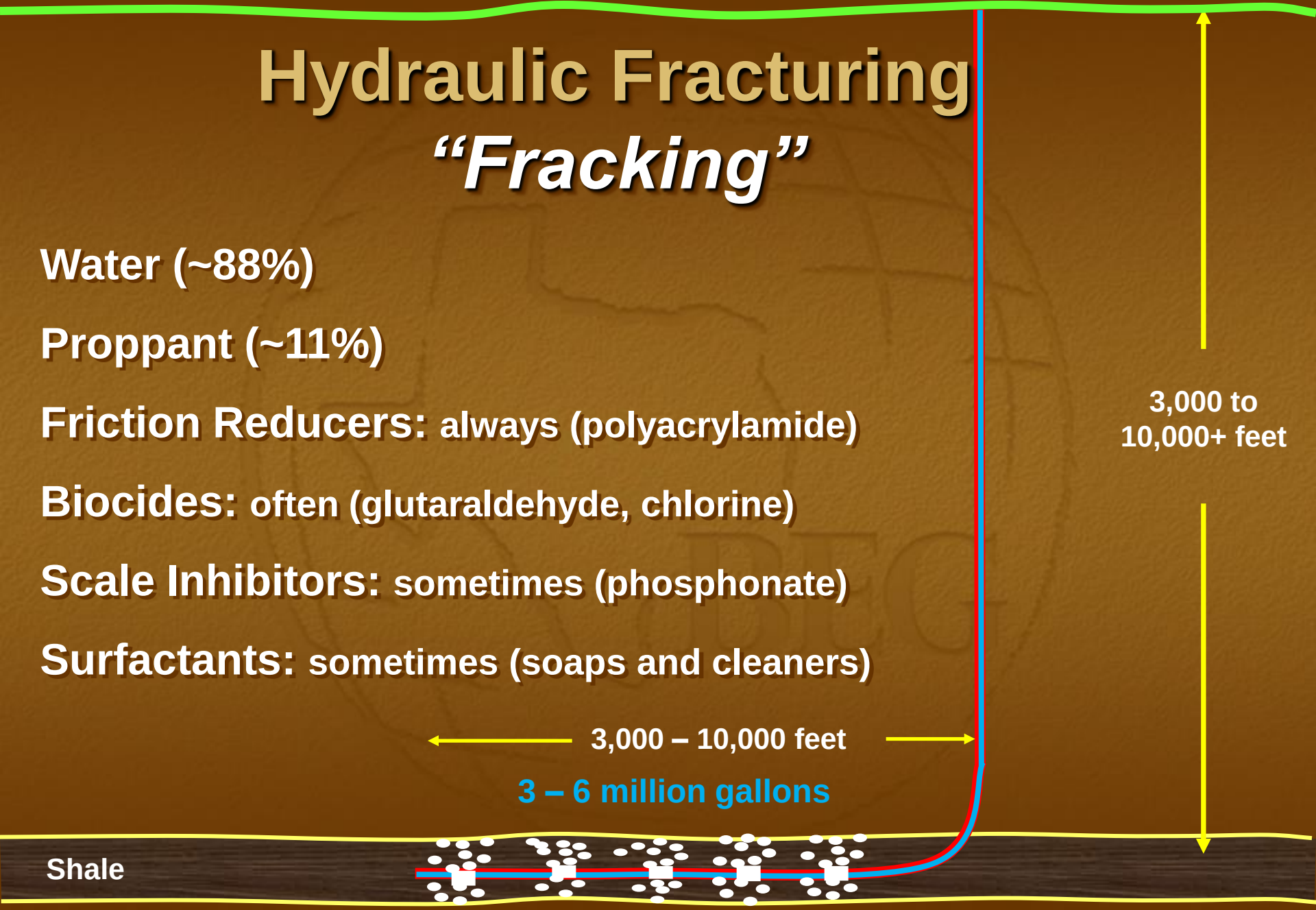
Proppant (~11%)

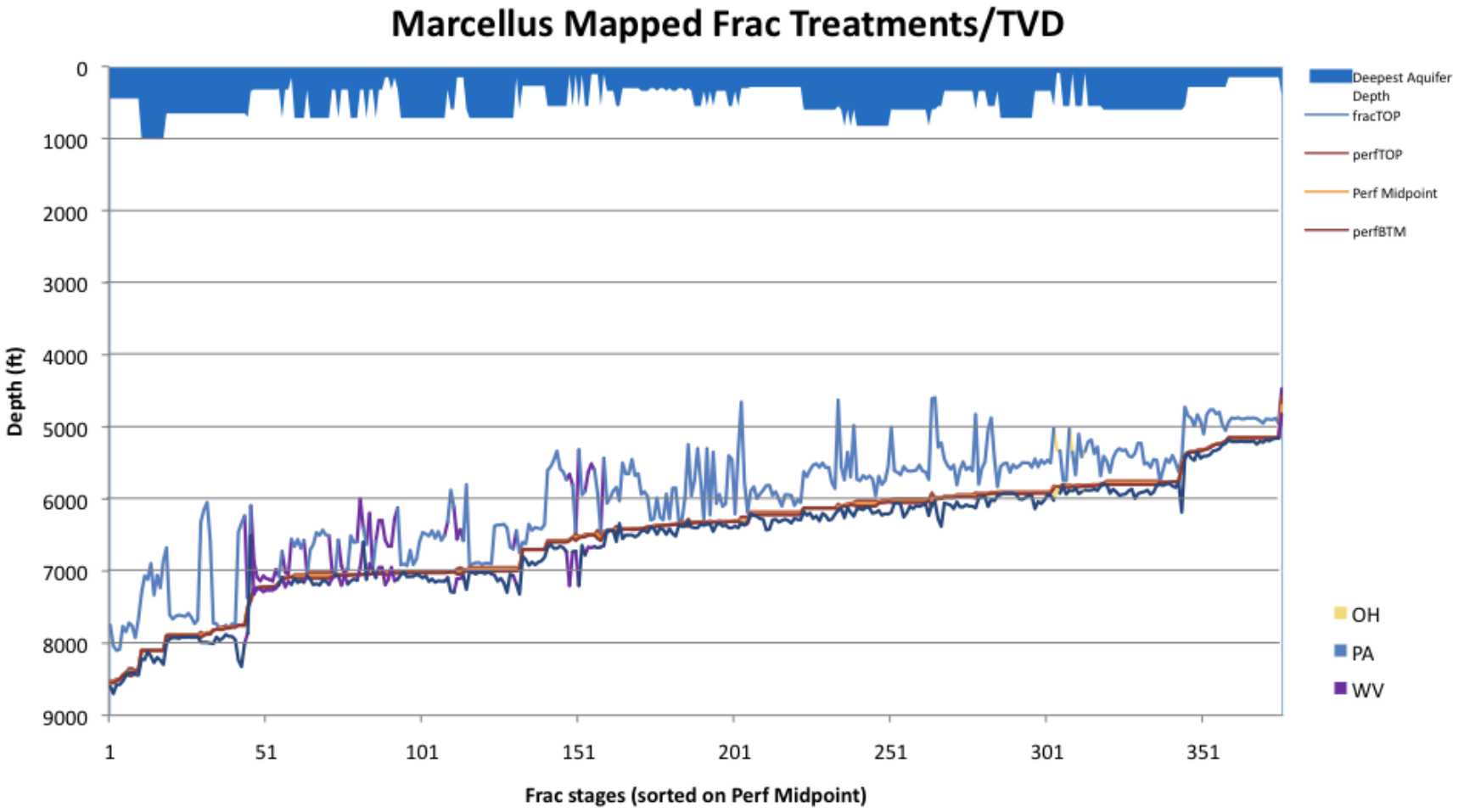
Friction Reducers: always (polyacrylamide)

Biocides: often (glutaraldehyde, chlorine)

Scale Inhibitors: sometimes (phosphonate)

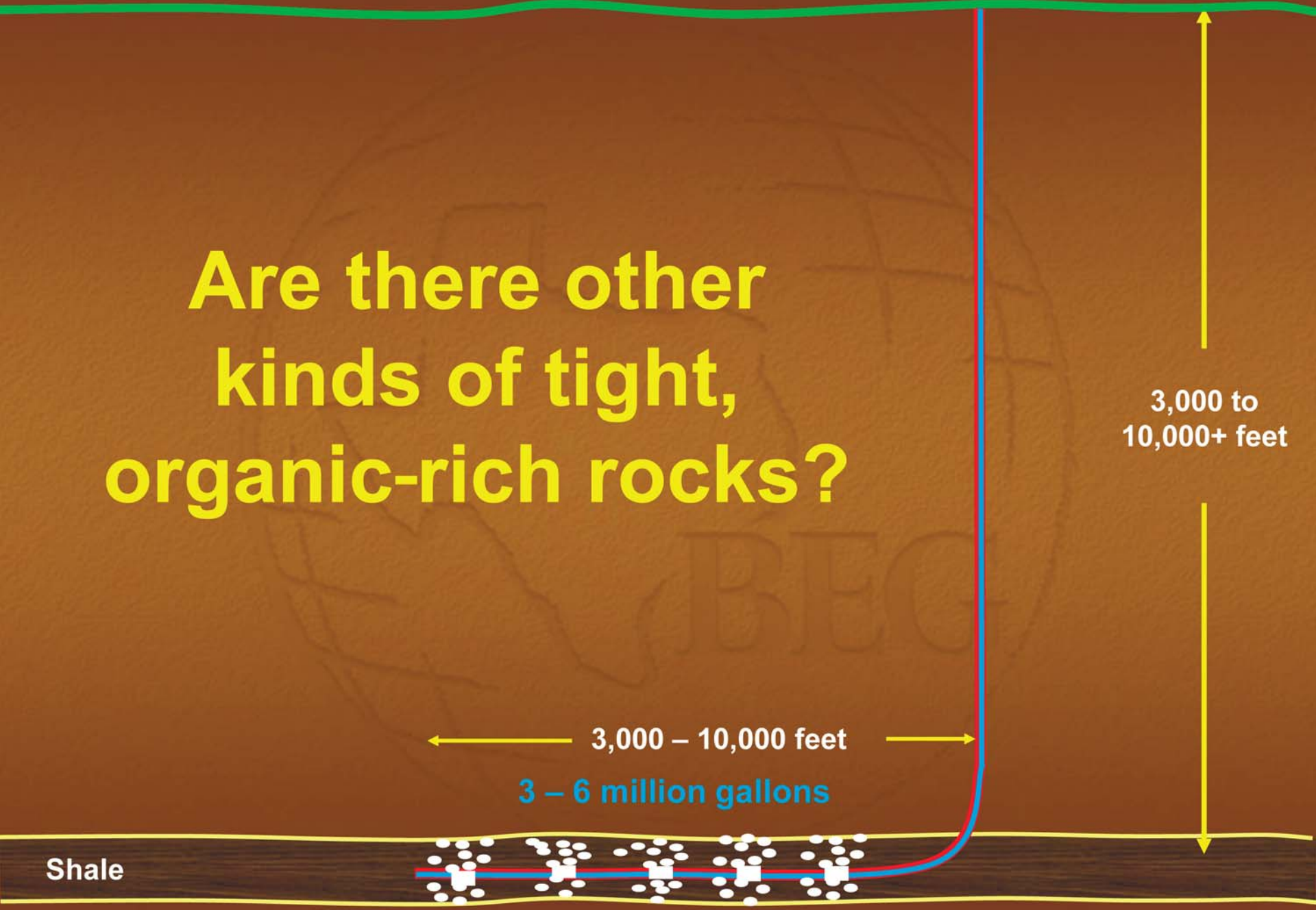
Surfactants: sometimes (soaps and cleaners)

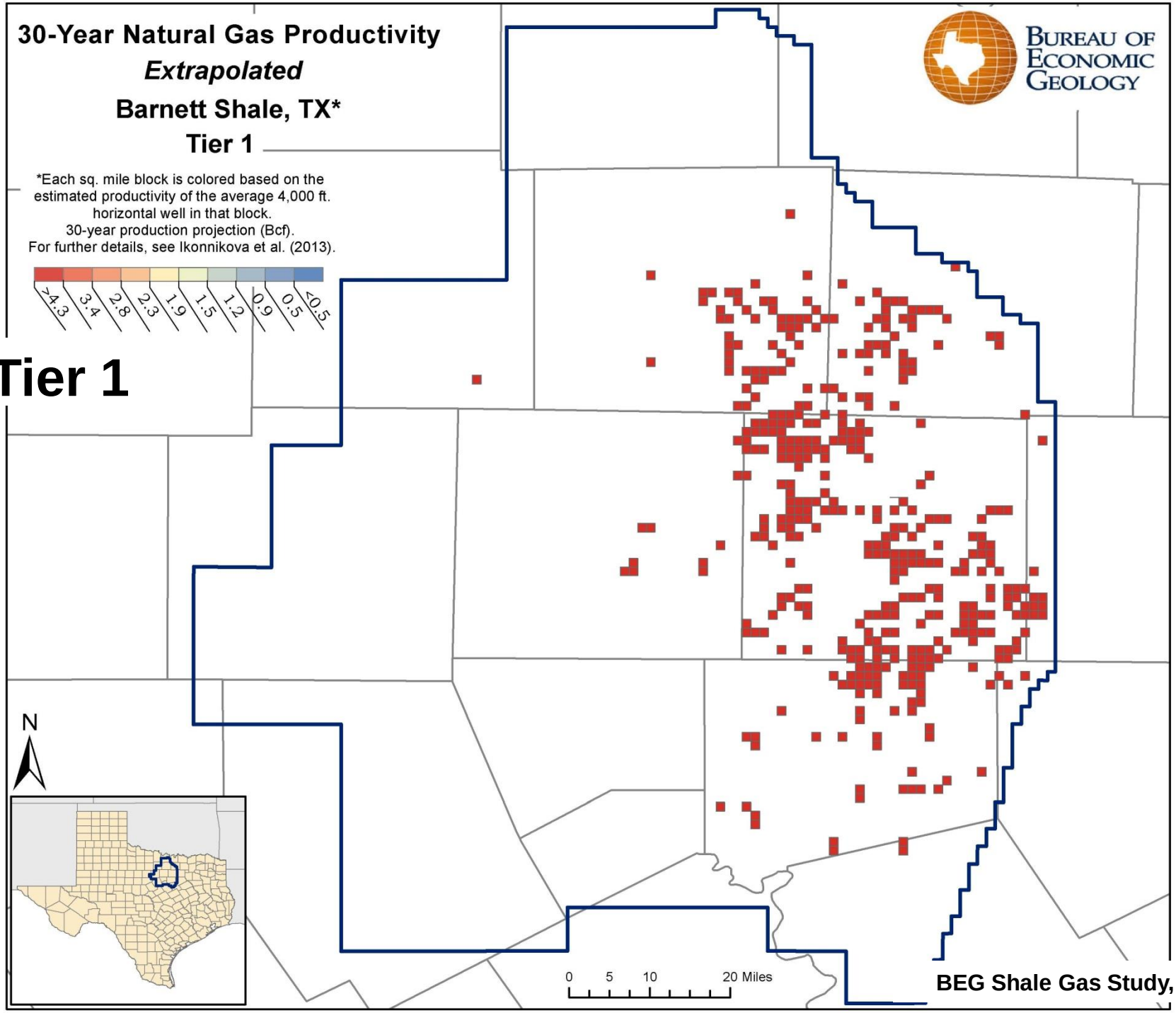




Pinnacle
A HALLIBURTON SERVICE

Are there other kinds of tight, organic-rich rocks?




30-Year Natural Gas Productivity
Extrapolated
Barnett Shale, TX*
Tier 1
*Each sq. mile block is colored based on the estimated productivity of the average 4,000 ft. horizontal well in that block.
30-year production projection (Bcf).
For further details, see Ikonnikova et al. (2013).
>4.3
3.4
2.8
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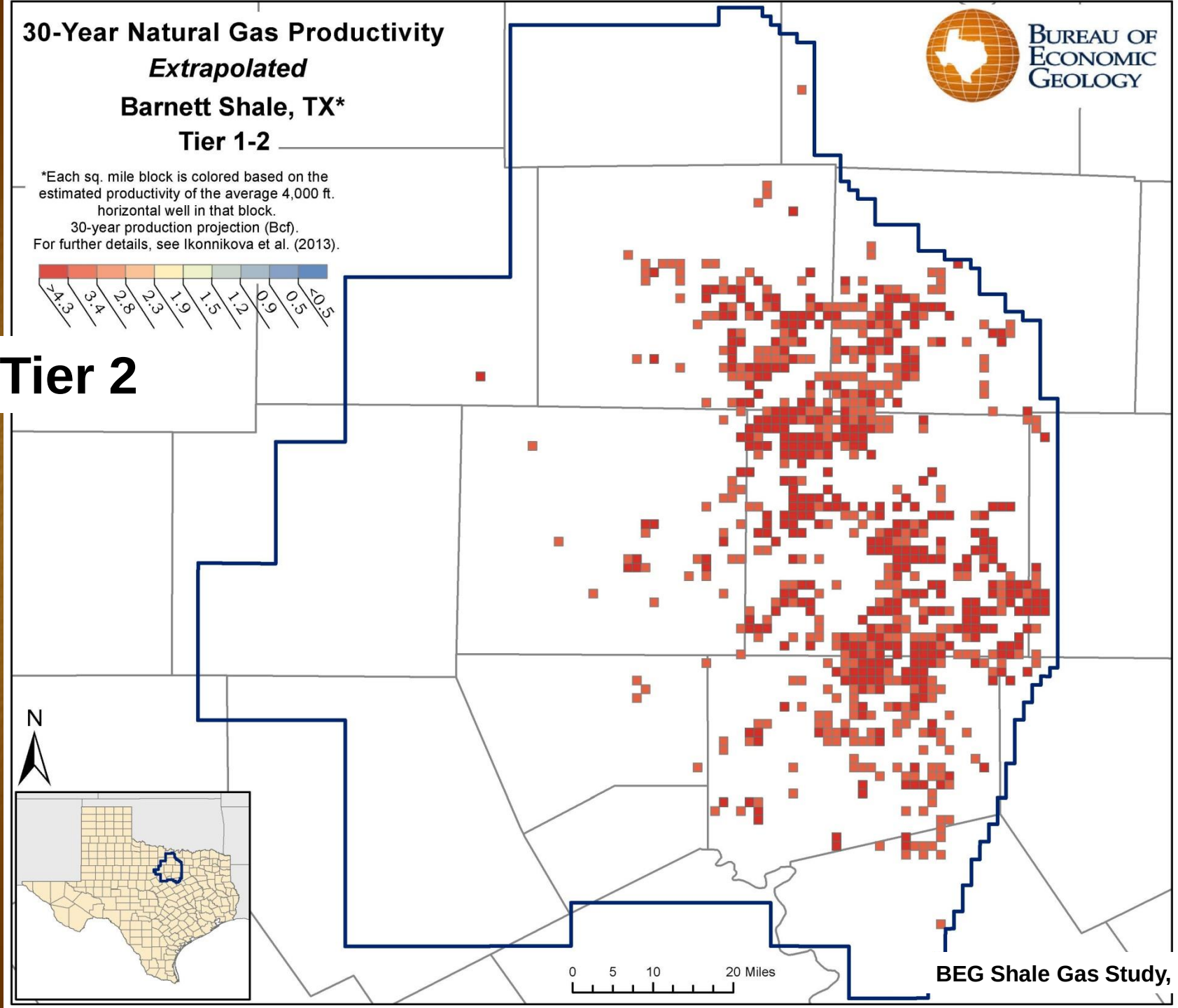
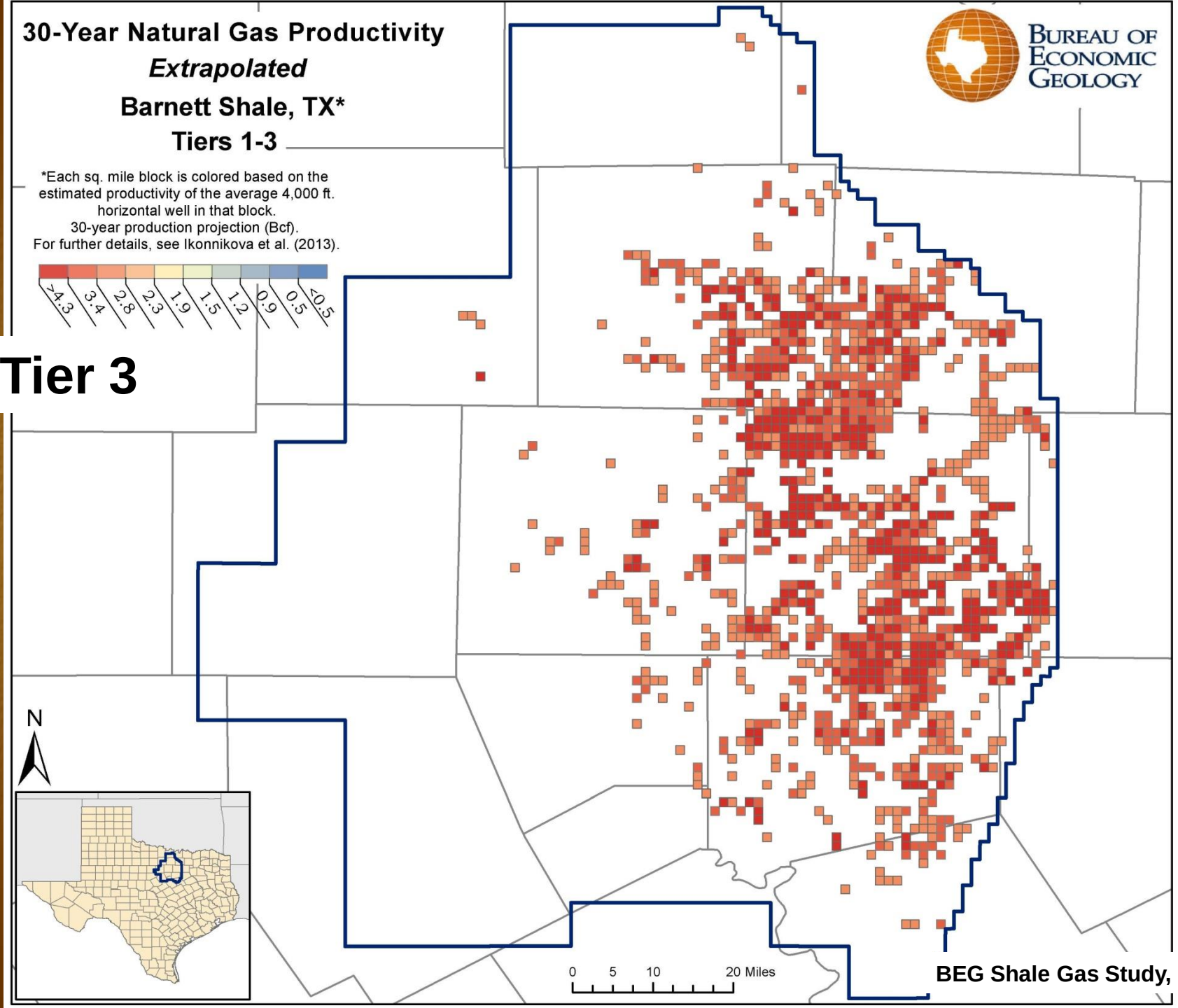
BUREAU OF ECONOMIC GEOLOGY
Tier 1
N
0 5 10 20 Miles
BEG Shale Gas Study, 2013



Tier 2

BEG Shale Gas Study, 2013


30-Year Natural Gas Productivity
Extrapolated
Barnett Shale, TX*
Tiers 1-3
*Each sq. mile block is colored based on the estimated productivity of the average 4,000 ft. horizontal well in that block.
30-year production projection (Bcf).
For further details, see Ikonnikova et al. (2013).
>4.3
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Tier 3
BUREAU OF ECONOMIC GEOLOGY
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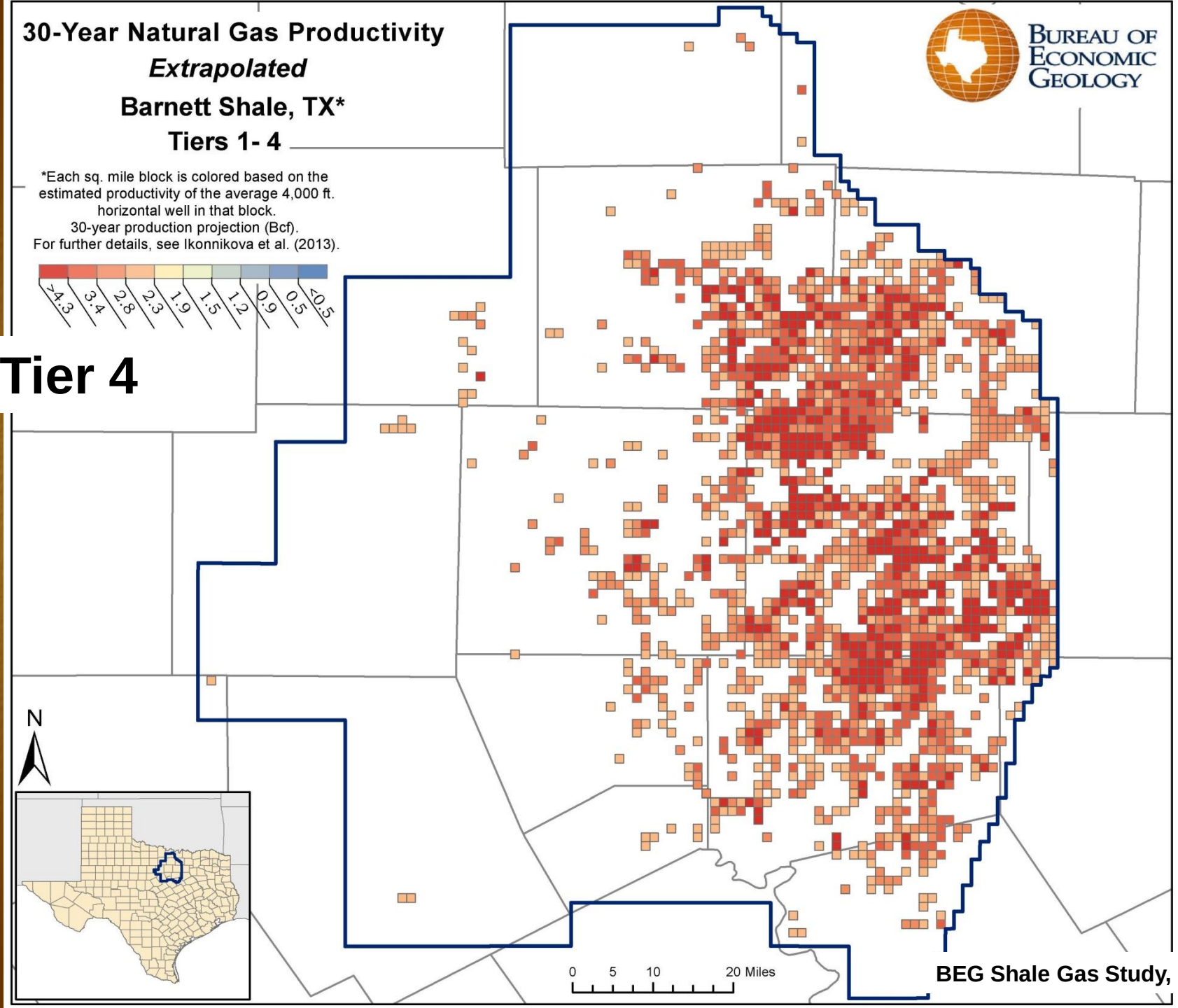
BEG Shale Gas Study, 2013


30-Year Natural Gas Productivity
Extrapolated
Barnett Shale, TX*
Tiers 1- 4
*Each sq. mile block is colored based on the estimated productivity of the average 4,000 ft. horizontal well in that block.
30-year production projection (Bcf).
For further details, see Ikonnikova et al. (2013).
>4.3
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Tier 4
BUREAU OF ECONOMIC GEOLOGY
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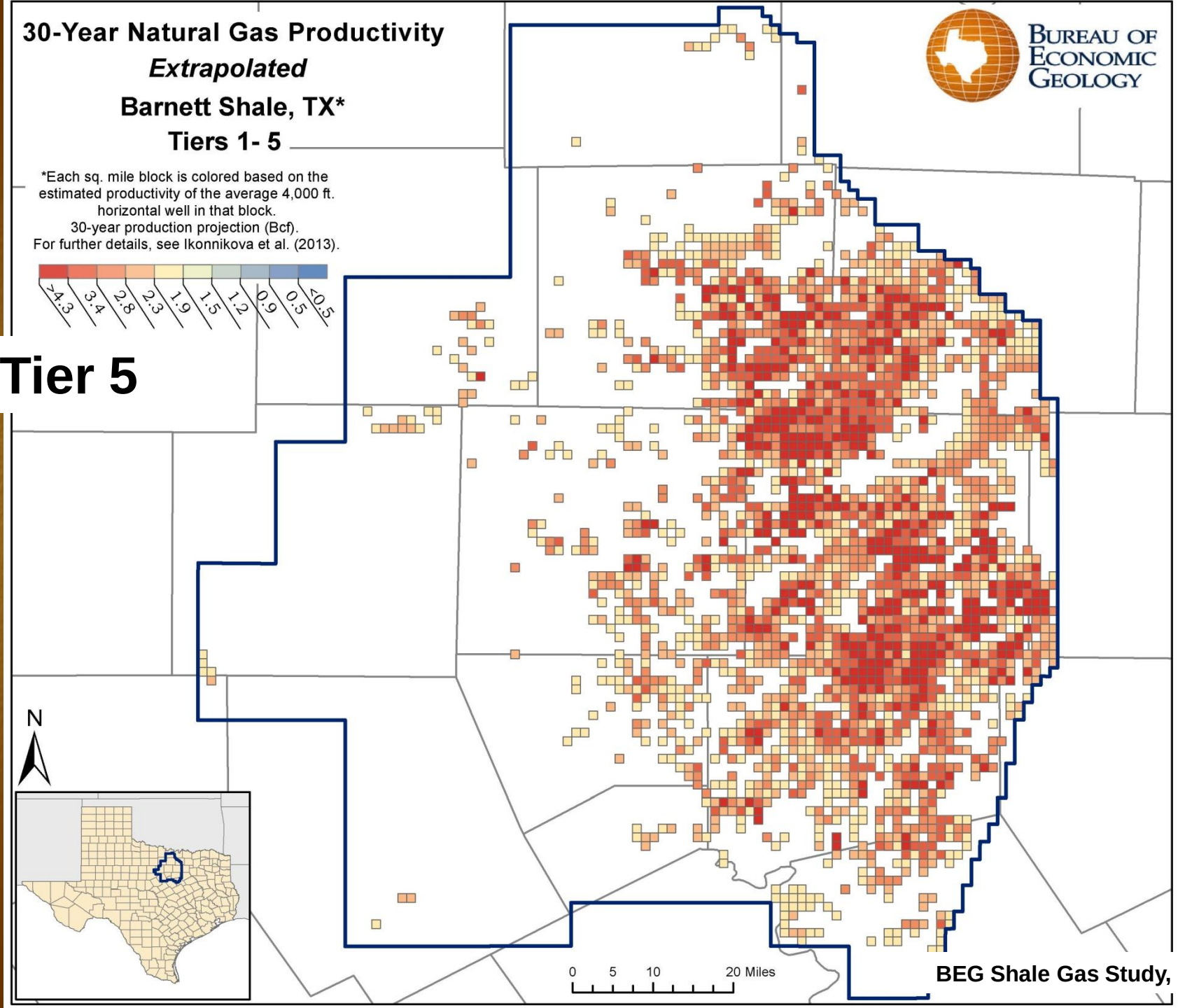
0 5 10 20 Miles
BEG Shale Gas Study, 2013


30-Year Natural Gas Productivity
Extrapolated
Barnett Shale, TX*
Tiers 1- 5
*Each sq. mile block is colored based on the estimated productivity of the average 4,000 ft. horizontal well in that block.
30-year production projection (Bcf).
For further details, see Ikonnikova et al. (2013).
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Tier 5
BUREAU OF ECONOMIC GEOLOGY
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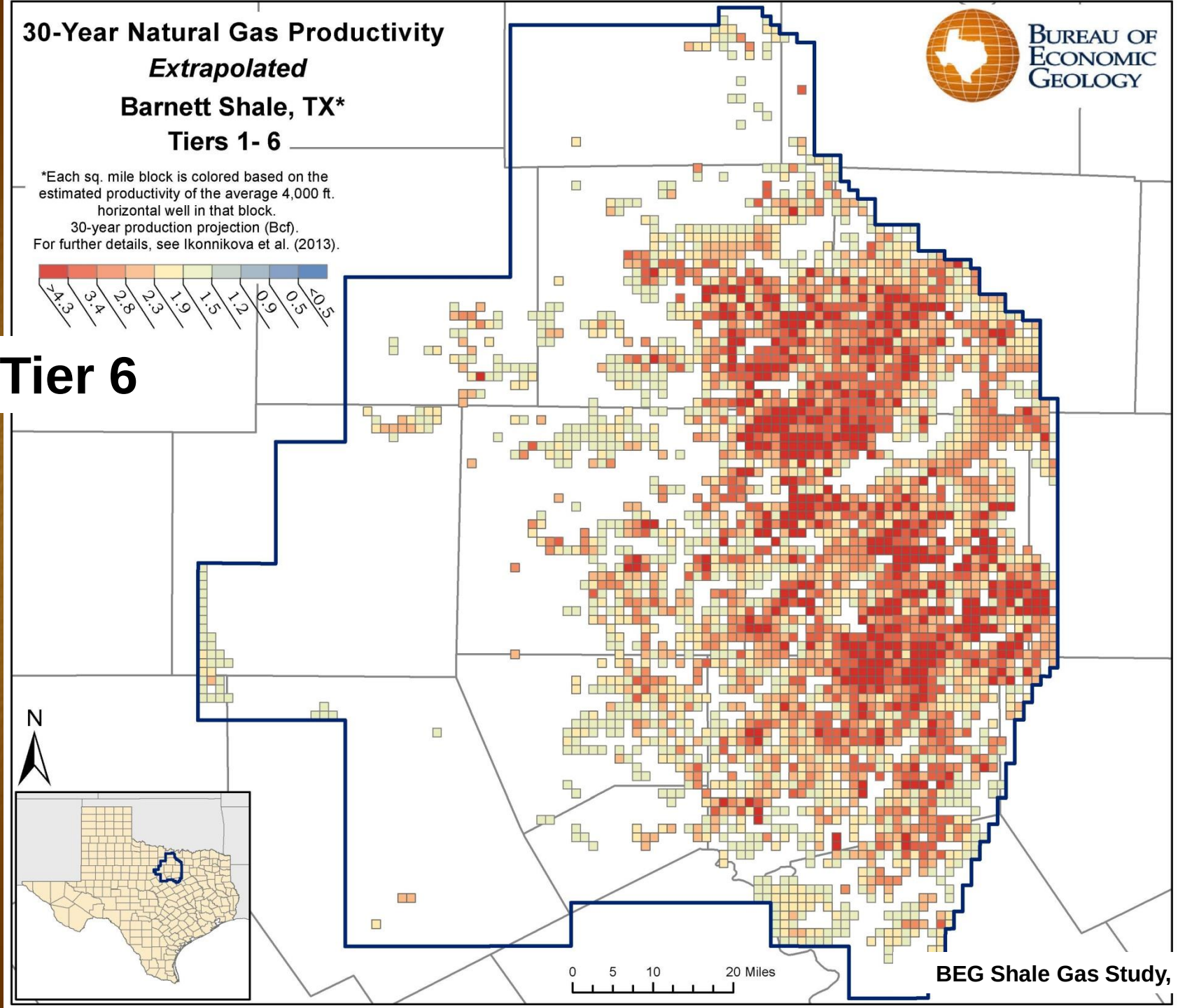
BEG Shale Gas Study, 2013


30-Year Natural Gas Productivity
Extrapolated
Barnett Shale, TX*
Tiers 1- 6
*Each sq. mile block is colored based on the estimated productivity of the average 4,000 ft. horizontal well in that block.
30-year production projection (Bcf).
For further details, see Ikonnikova et al. (2013).
>4.3
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Tier 6
BUREAU OF ECONOMIC GEOLOGY
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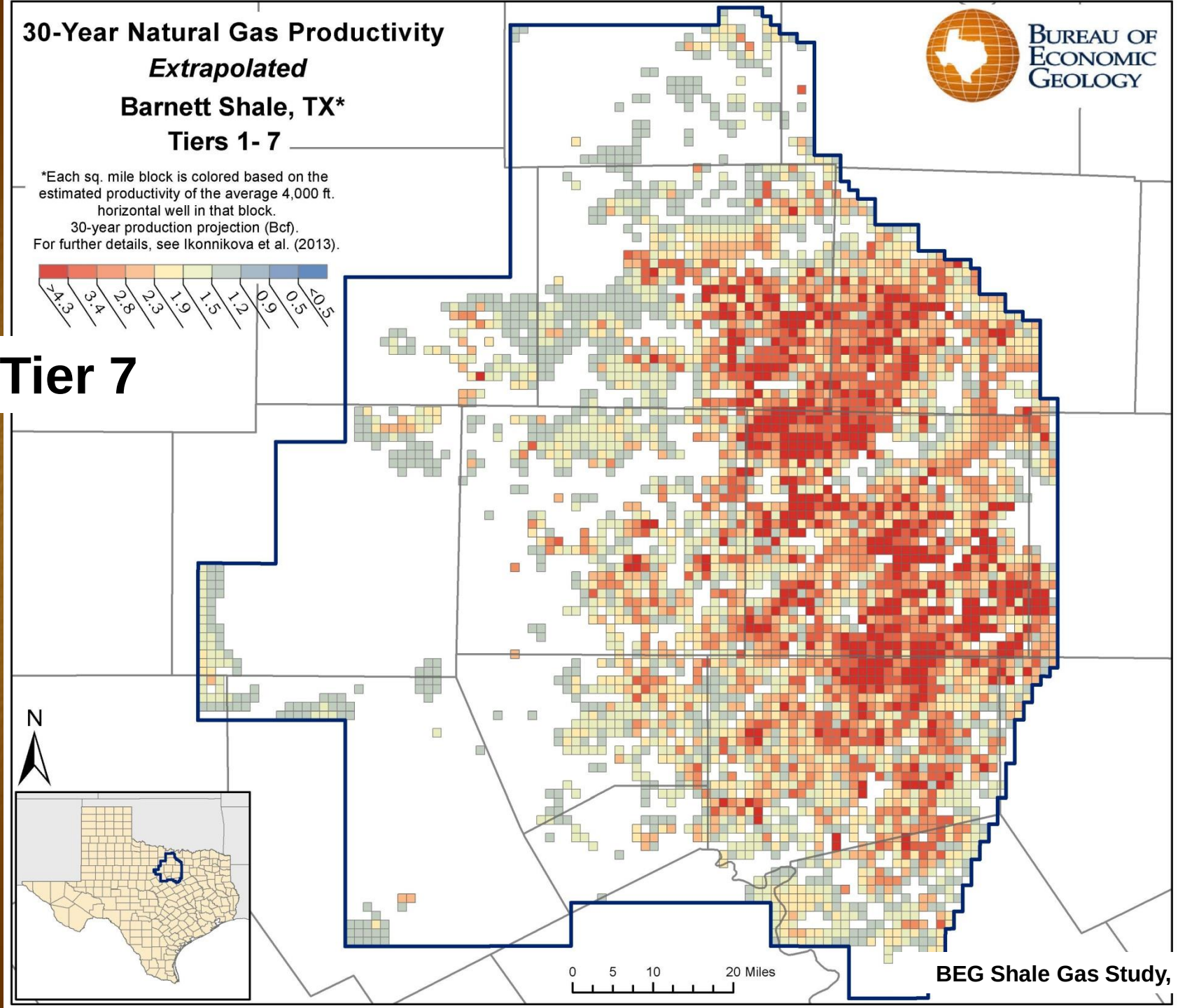
BEG Shale Gas Study, 2013


30-Year Natural Gas Productivity
Extrapolated
Barnett Shale, TX*
Tiers 1- 7
*Each sq. mile block is colored based on the estimated productivity of the average 4,000 ft. horizontal well in that block.
30-year production projection (Bcf).
For further details, see Ikonnikova et al. (2013).
>4.3
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Tier 7
BUREAU OF ECONOMIC GEOLOGY
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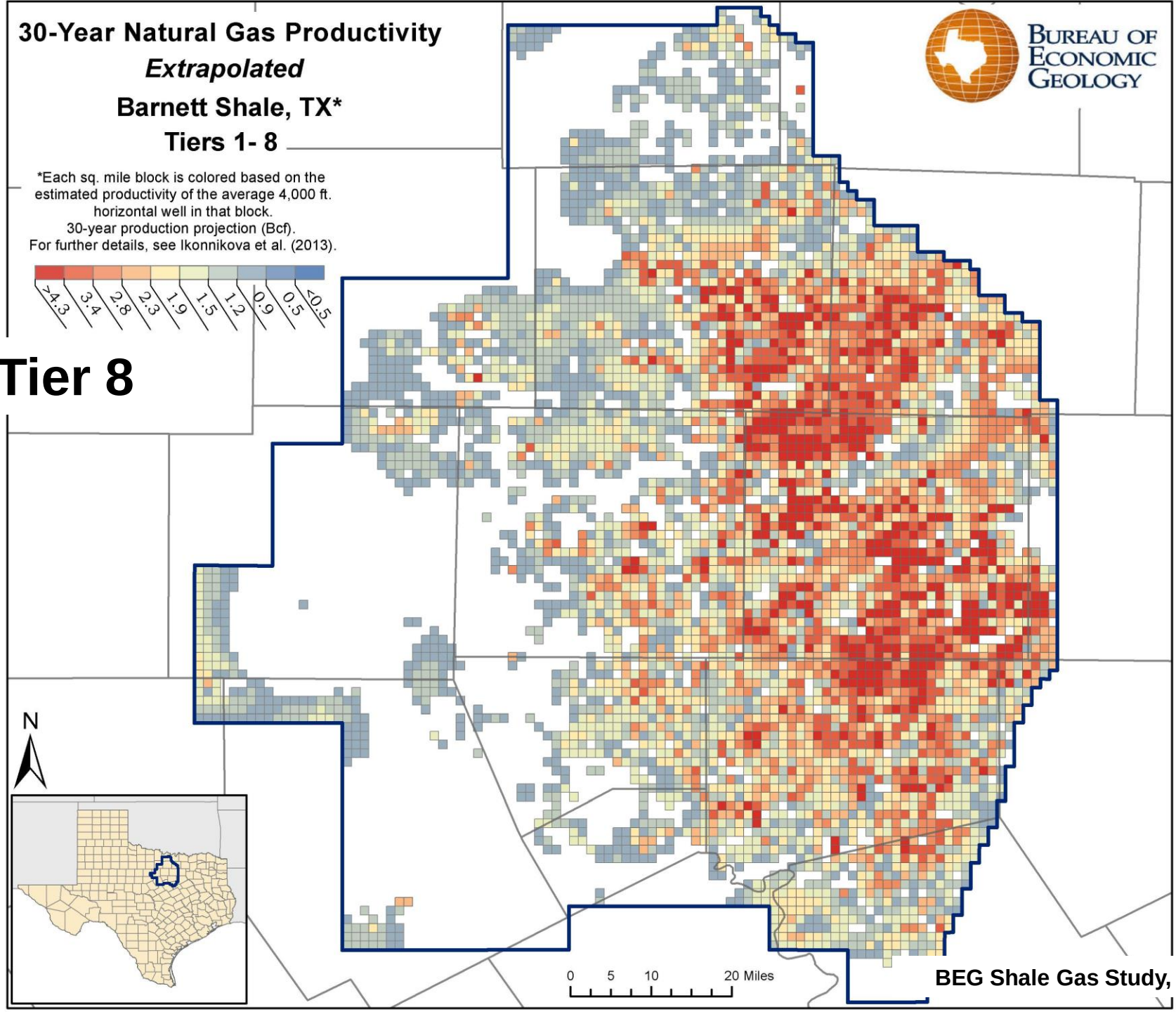
0 5 10 20 Miles
BEG Shale Gas Study, 2013


30-Year Natural Gas Productivity
Extrapolated
Barnett Shale, TX*
Tiers 1- 8
*Each sq. mile block is colored based on the estimated productivity of the average 4,000 ft. horizontal well in that block.
30-year production projection (Bcf).
For further details, see Ikonnikova et al. (2013).
>4.3
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Tier 8
BUREAU OF ECONOMIC GEOLOGY
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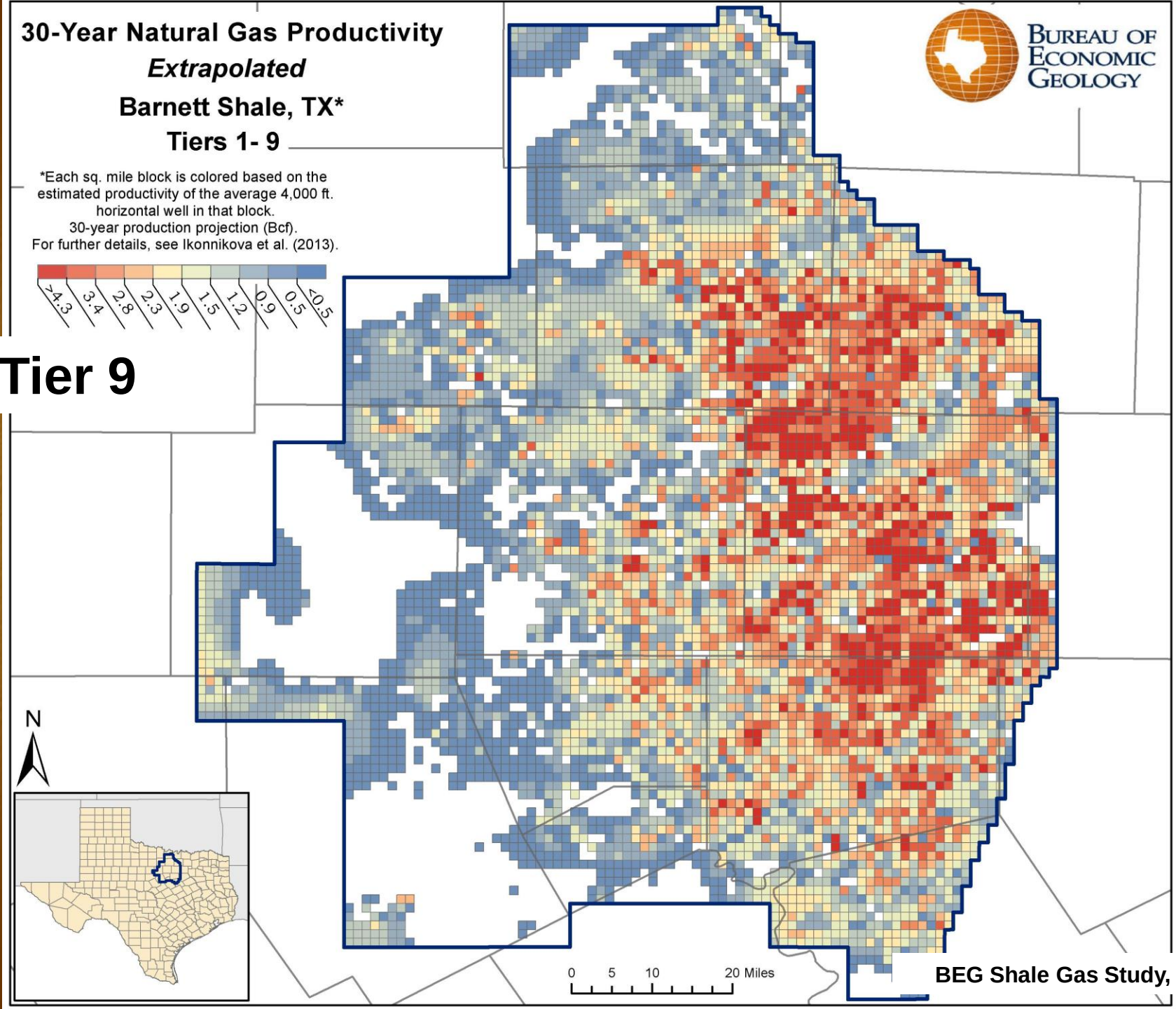
0 5 10 20 Miles
BEG Shale Gas Study, 2013


30-Year Natural Gas Productivity
Extrapolated
Barnett Shale, TX*
Tiers 1- 9
*Each sq. mile block is colored based on the estimated productivity of the average 4,000 ft. horizontal well in that block.
30-year production projection (Bcf).
For further details, see Ikonnikova et al. (2013).
>4.3
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Tier 9
BUREAU OF ECONOMIC GEOLOGY
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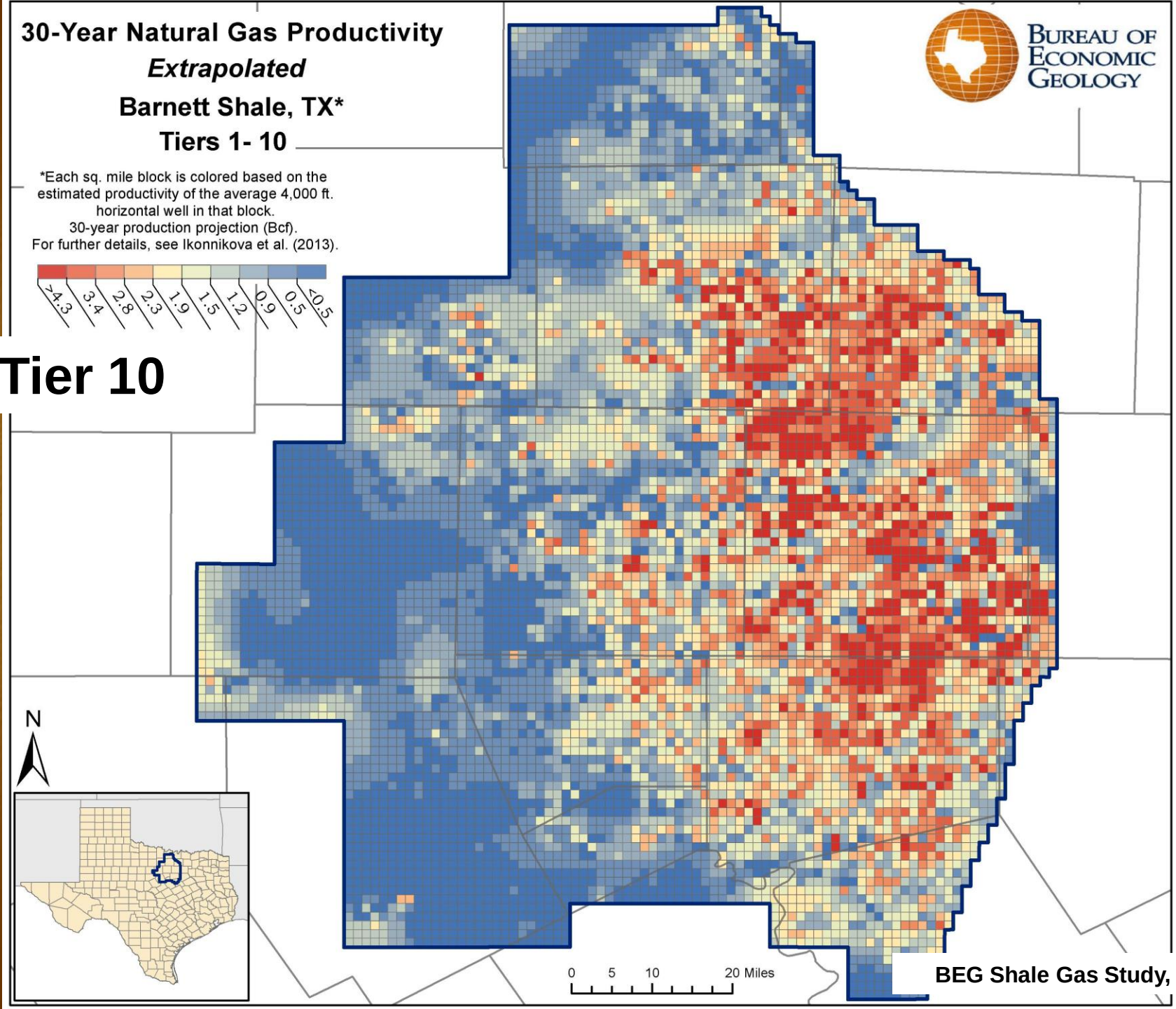
0 5 10 20 Miles
BEG Shale Gas Study, 2013


30-Year Natural Gas Productivity
Extrapolated
Barnett Shale, TX*
Tiers 1- 10
*Each sq. mile block is colored based on the estimated productivity of the average 4,000 ft. horizontal well in that block.
30-year production projection (Bcf).
For further details, see Ikonnikova et al. (2013).
>4.3
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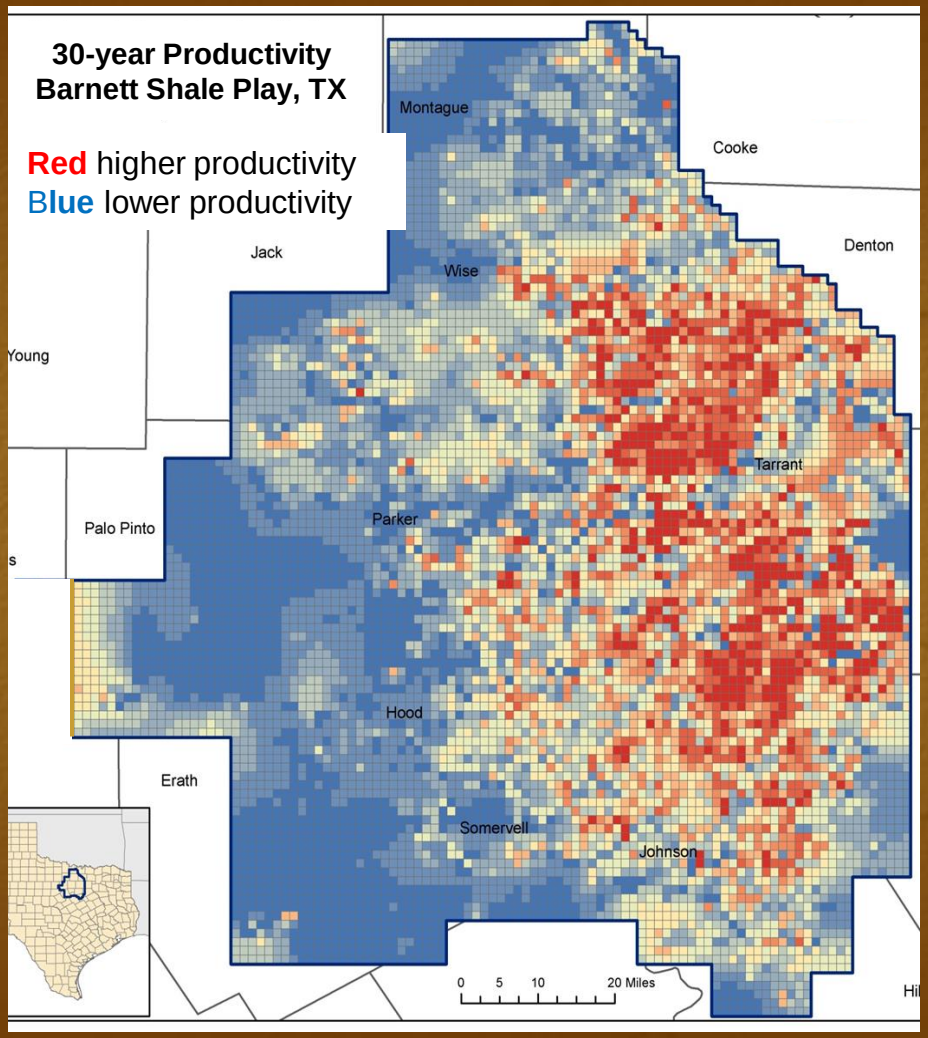
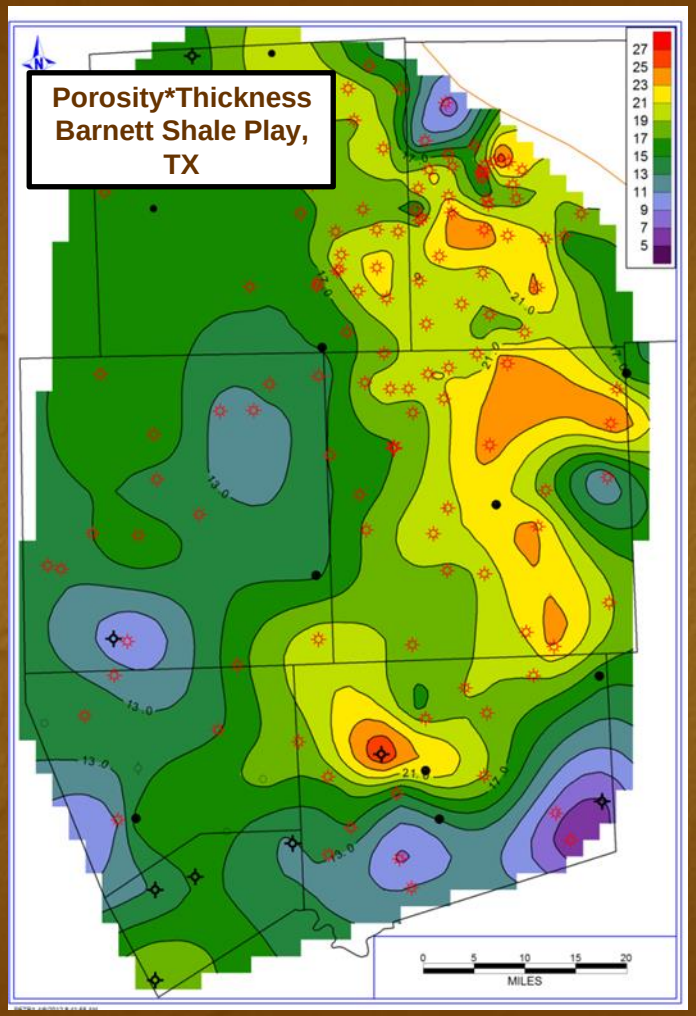
Tier 10
BUREAU OF ECONOMIC GEOLOGY
N
0 5 10 20 Miles
BEG Shale Gas Study, 2013

Tinker, 2013

Geologic Analysis

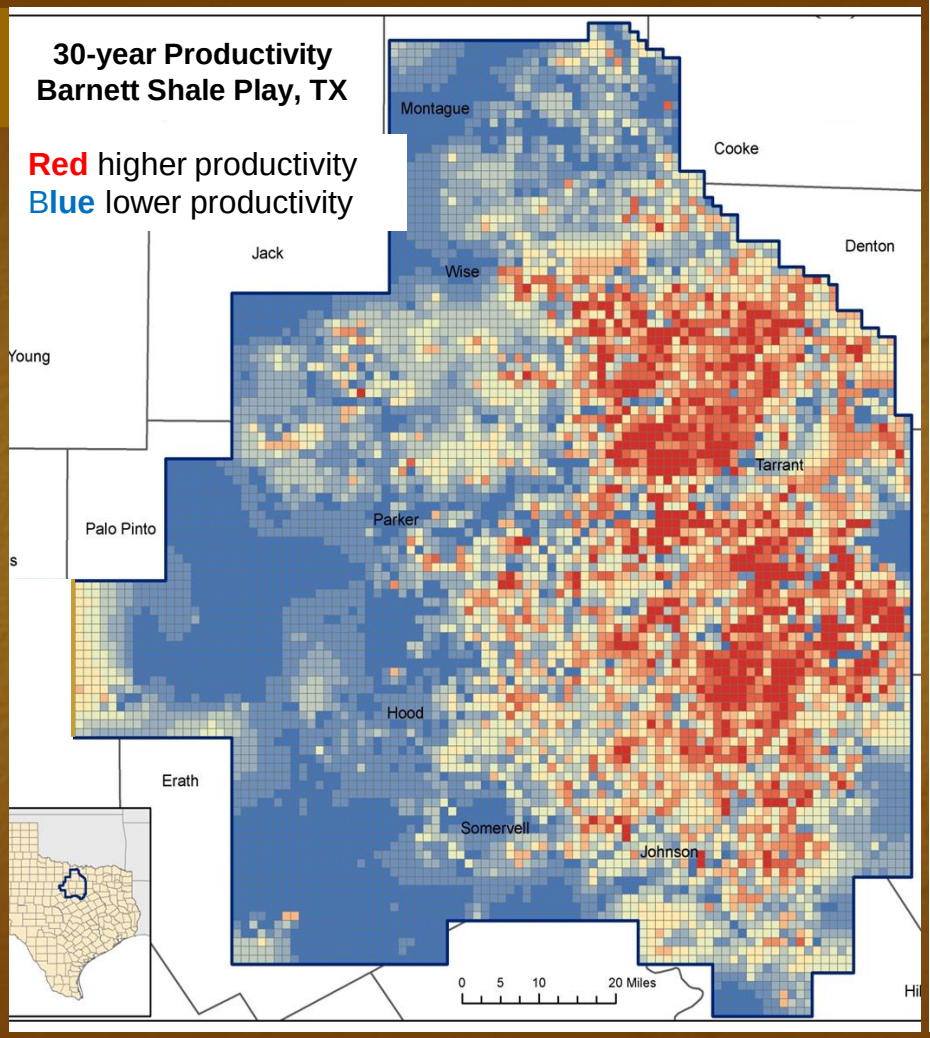


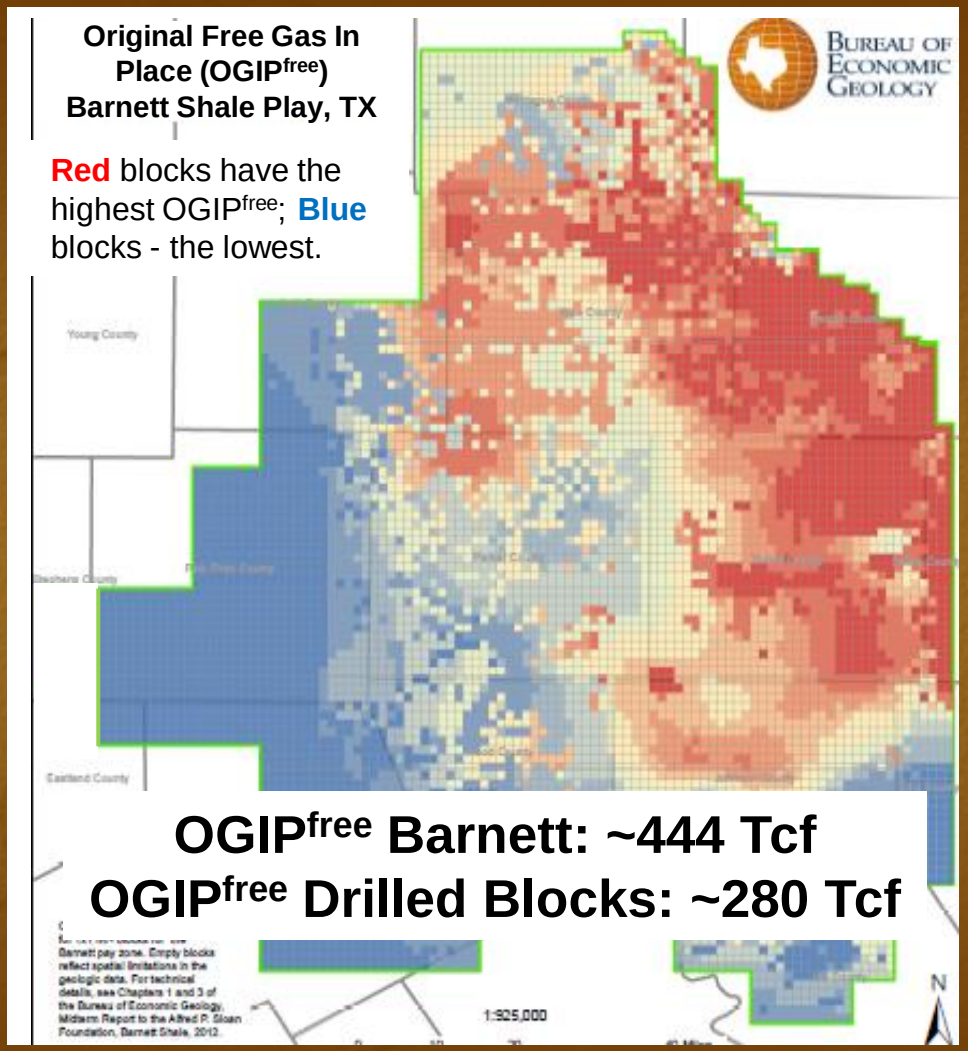


- We estimate the content of natural gas in the formation for each 1 mi^2 of the Barnett Shale.

BEG Shale Gas Study, 2013

Geologic Analysis





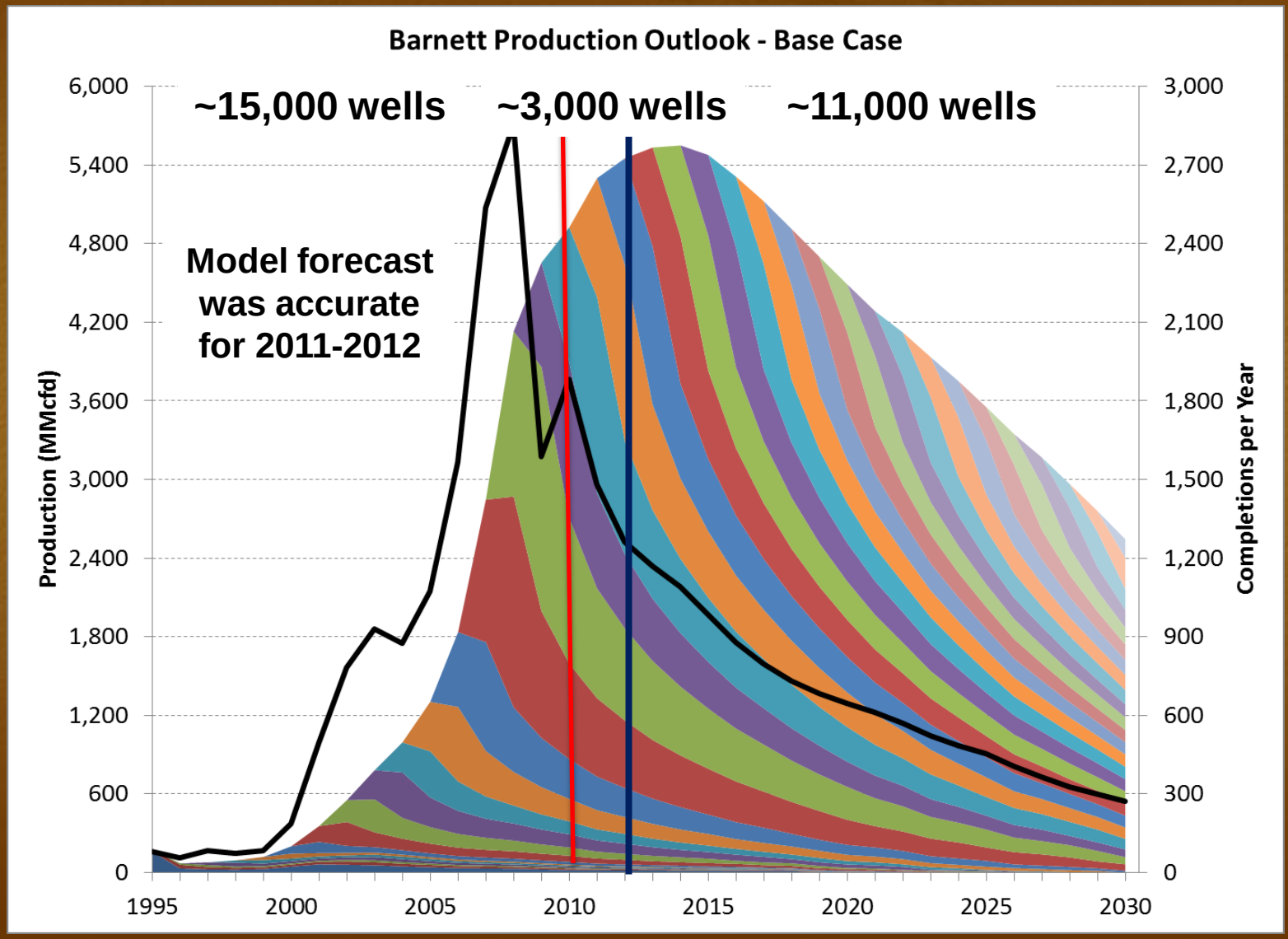
- We estimate the content of natural gas in the formation for each 1 mi^2 of the Barnett Shale.

Barnett

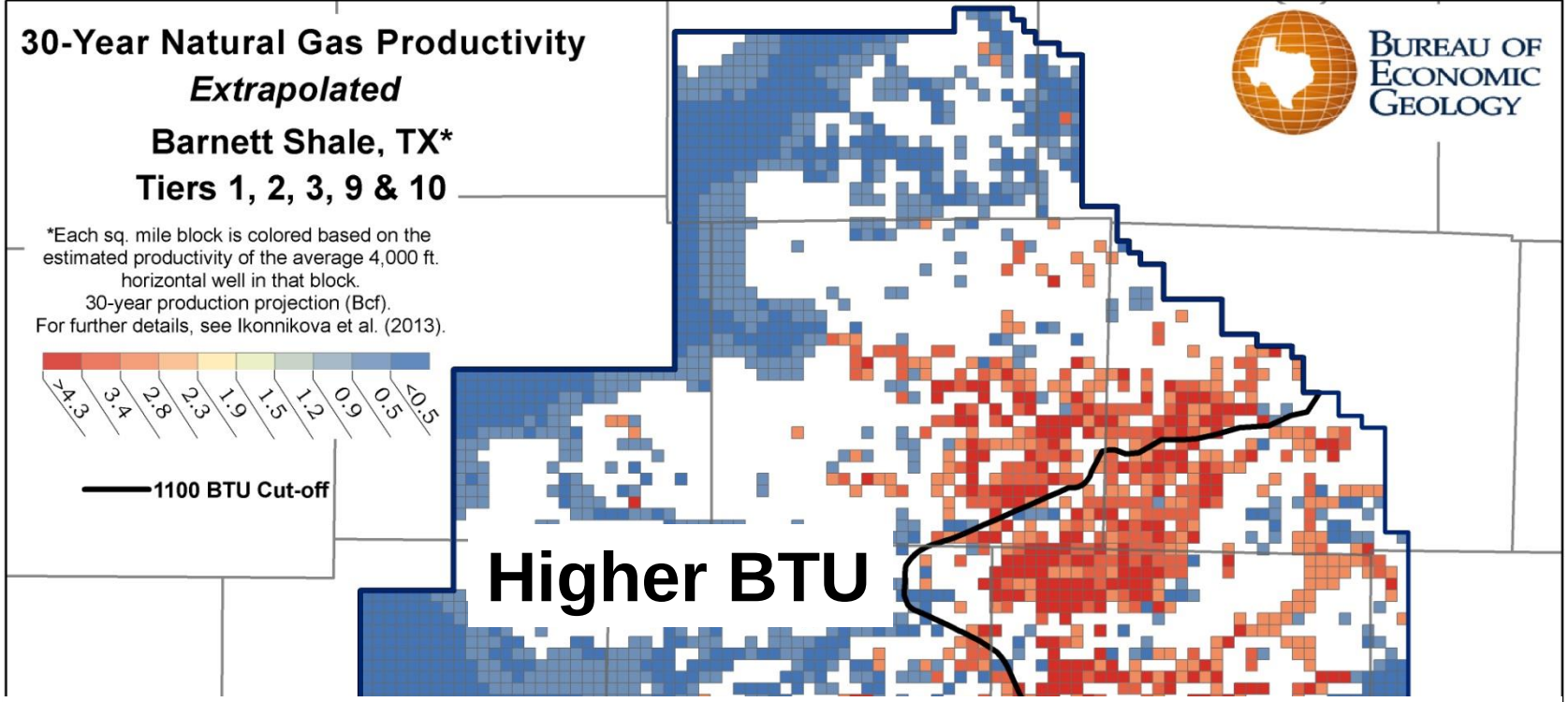
Assumption	*Base case*
- Henry Hub price for natural gas	$4.00/MMBtu
- Partly drained acreage developable ceiling	80%
- Undrilled acreage developable ceiling	15%
- WTI price	$80/bbl
- GPL/WTI price ratio	45%
- Annual technology improvement	0.39%
- Annual well-cost improvement	0.24%
- Economic limit for shutting-in a well (dry)	0.05 MMcf/d
- Economic limit for shutting-in a well (high Btu)	0.029 MMcf/d
- Minimum completions in a year (dry)	20 (Tiers 1–4) 2 (Tiers 5–10)
- Minimum completions in a year (high Btu)	25 (Tiers 2–5) 10 (Tiers 1, 6–10)

Tinker, 2013

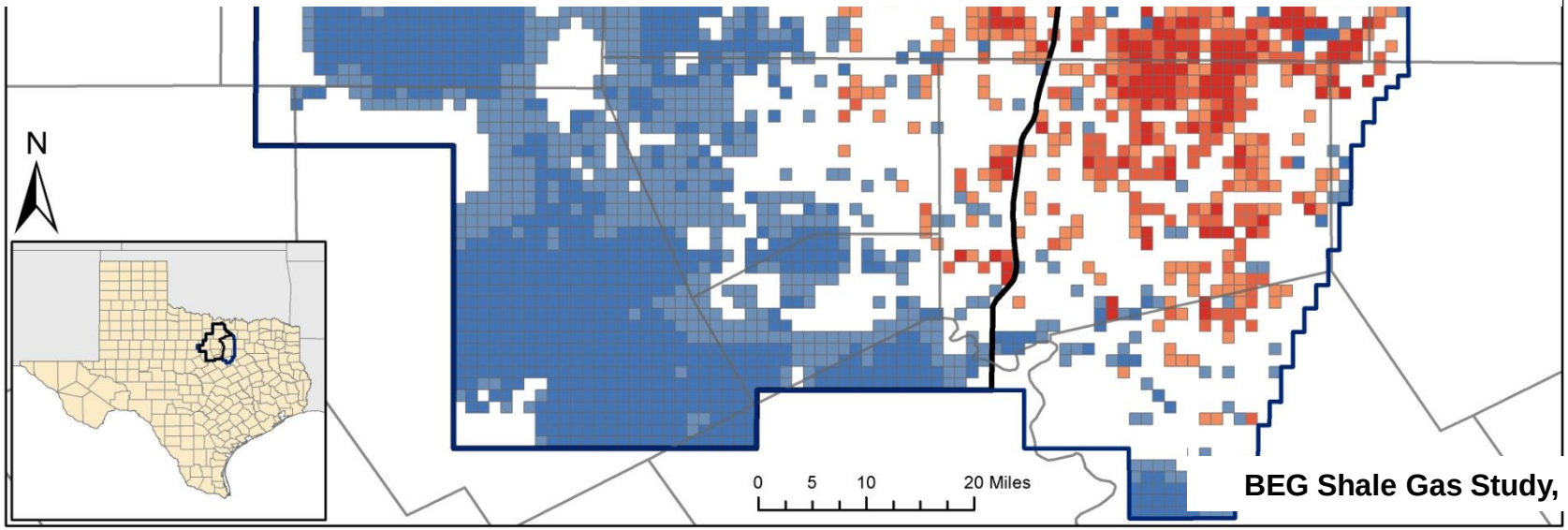
Barnett
Production Outlook



BEG Shale Gas Study, 2013



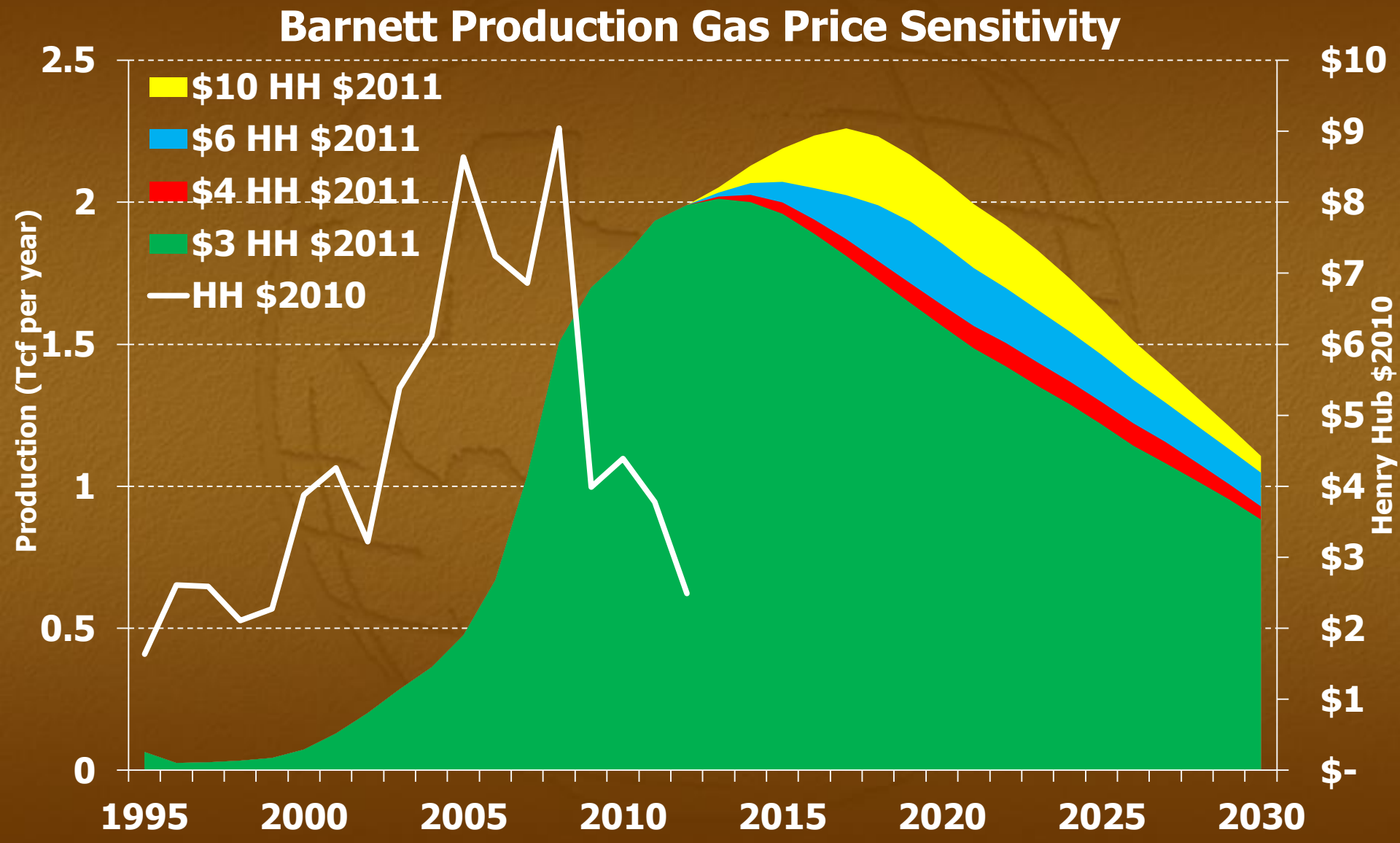
Opportunities for the Independent?



BEG Shale Gas Study, 2013

Barnett Shale: *Base Case*

Tinker, 2013



BEG Shale Gas Study, 2013

Barnett Shale: *Base Case*

Tinker, 2013

Base Case Scenarios	2030 Annual Prod (Bcf)	Cum prod thru 2050 (Tcf)
$3	883	43.7
$4	929	45.1
$6	1048	48.1
$10	1106	51.0

Press

UT Press Release http://www.utexas.edu/news/2013/02/28/new-rigorous-assessment-of-shale-gas-reserves-forecasts-reliable-supply-from-barnett-shale-through-2030/

Gas Boom Projected to Grow for Decades
Russell Gold, Wall Street Journal Front Page, Feb. 28
http://online.wsj.com/article/SB10001424127887323293704578330700203397128.html

Texas Study Points To A Longer Natural Gas Boom
Wade Goodwynm, NPR All Things Considered
http://www.npr.org/2013/02/28/173173548/texas-study-points-to-a-longer-natural-gas-boom

U.S. Barnett shale to pump natural gas to 2050
Reuters, Feb. 28
http://uk.reuters.com/article/2013/02/28/usa-natgas-barnett-idUKL1N0BSDKC20130228

Barnett Shale Output to Tumble Through 2030, Study Says
Bloomberg, Joe Carroll, Feb. 28
http://www.bloomberg.com/news/2013-02-28/barnett-shale-output-to-tumble-through-2030-study-says.html

Unconventional Reservoirs
Environmental Implications

- Environmental
  - Traffic/noise/light
  - Land
  - Quakes
  - Water
  - NORM
  - Methane and Carbon

Unconventional Reservoirs

Environmental Implications

- Environmental
  - Traffic/noise/light
  - Land
  - Quakes
  - Water
  - NORM
  - Methane and Carbon
- Security
  - Available
  - Affordable
  - Reliable

Not mutually exclusive!

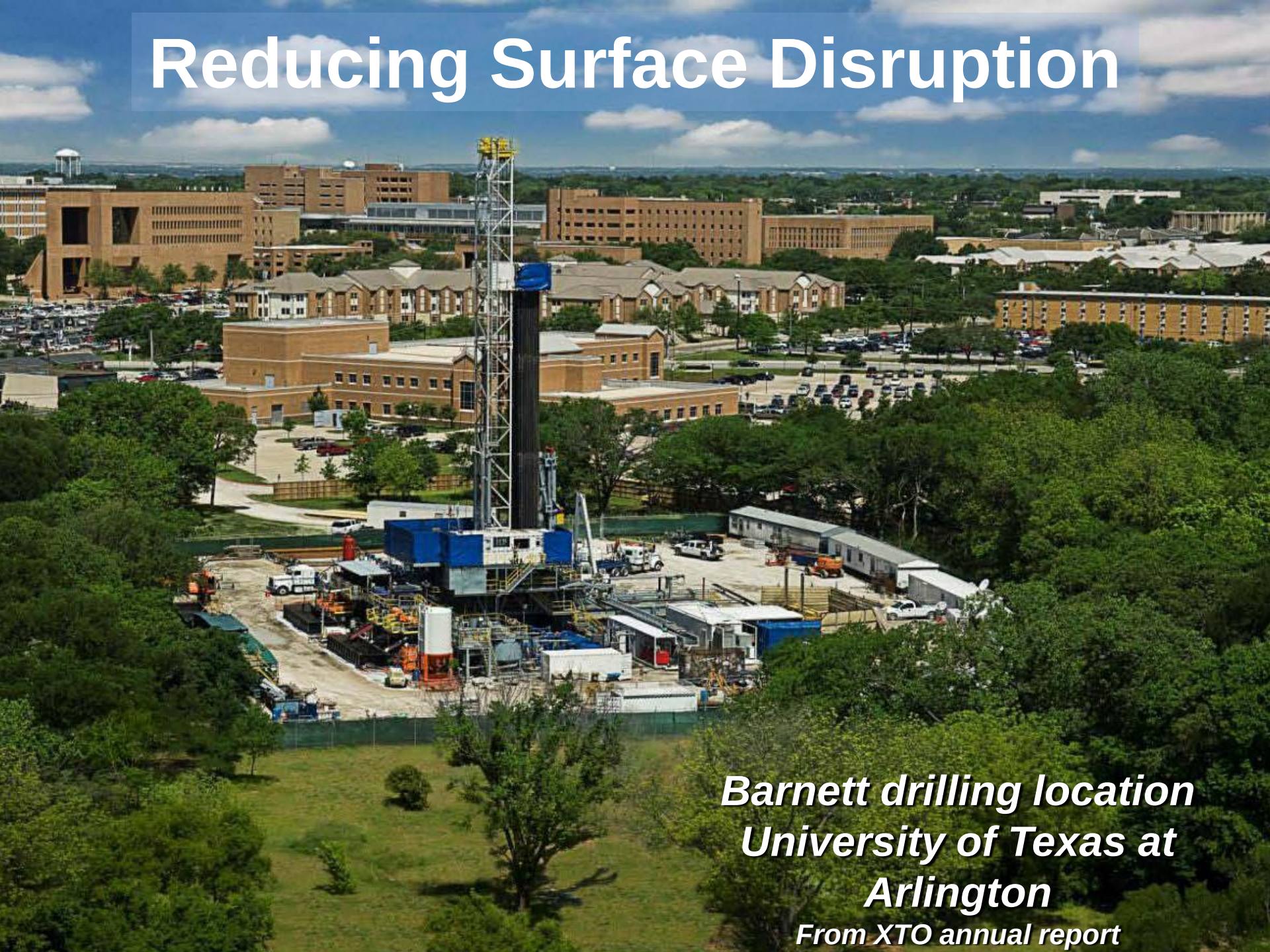
Tinker, 2013

Environmental Issues
Regulatory Considerations

I. **Mandatory baseline data**
II. **Cement all gas-producing zones**
III. **Minimize fresh-water use on the front end**
IV. **Full disclosure of chemicals**
V. **Handle flowback and produced water**
    a. **Treat and reuse**
    b. **Dispose: characterize for faults**
VI. **Minimize methane emissions**
VII. **Minimize surface impact**

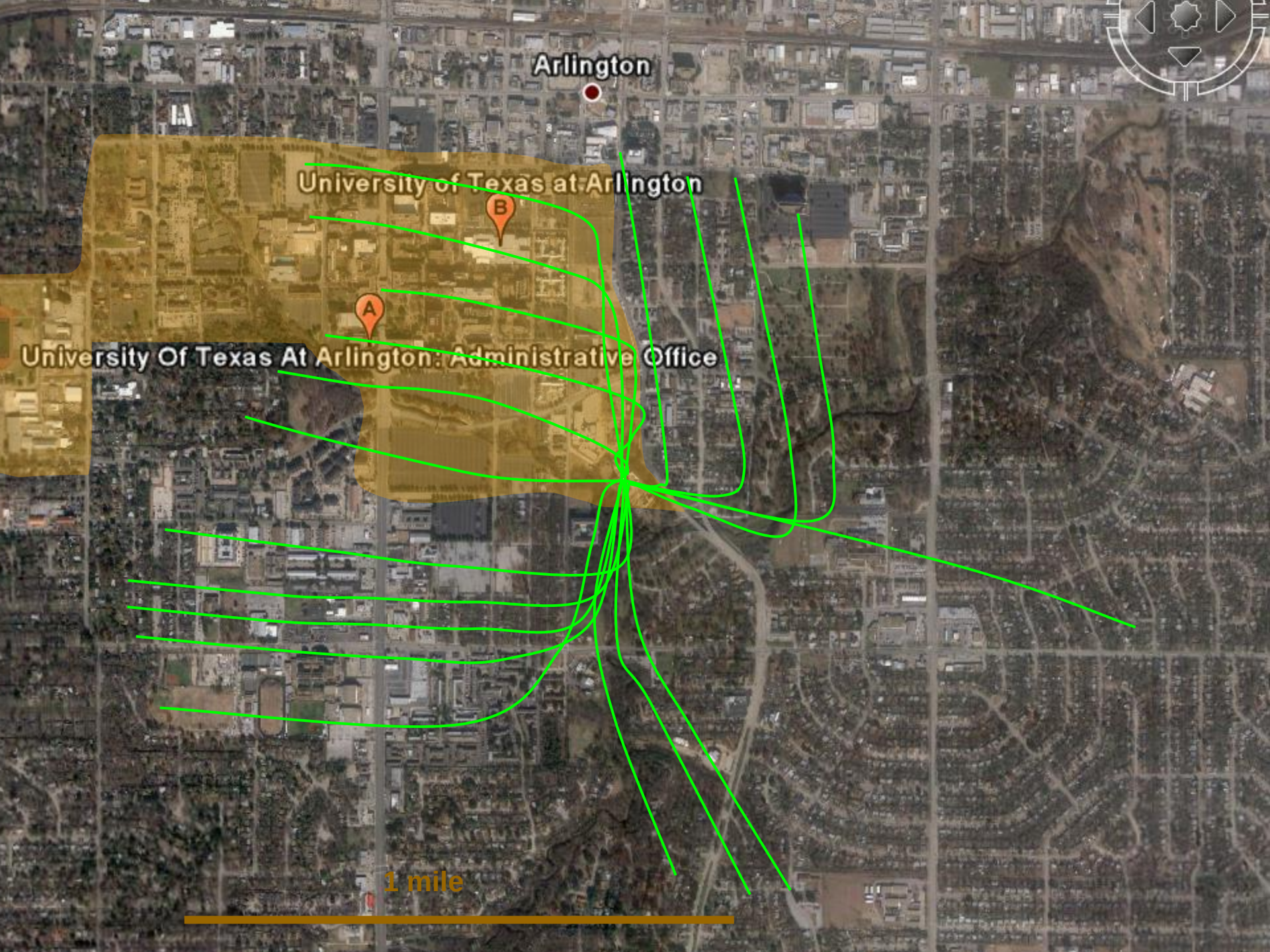
after Rao, 2012

Reducing Surface Disruption



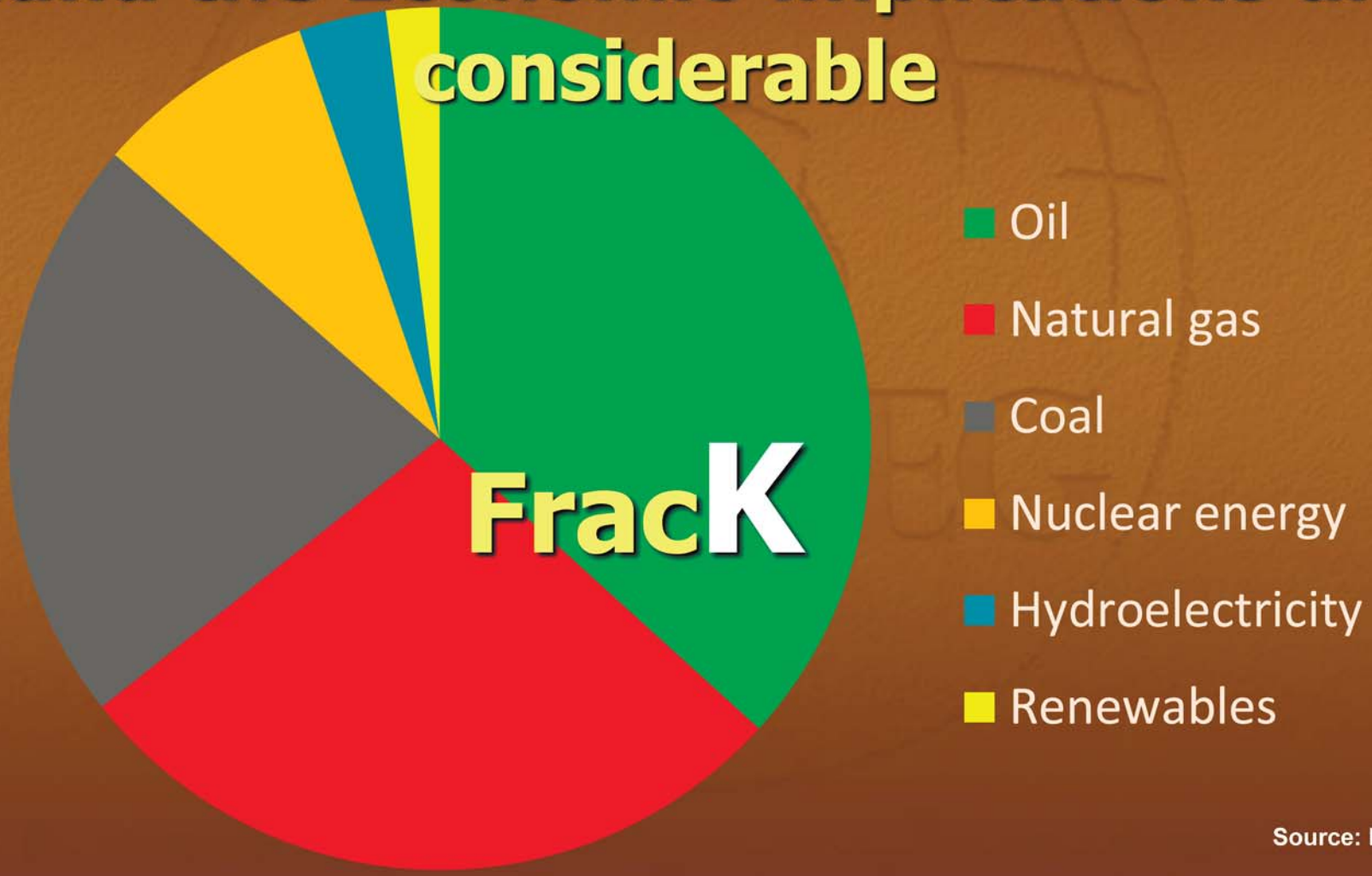
Barnett drilling location University of Texas at Arlington

From XTO annual report


Arlington
University of Texas at Arlington
B
A
University Of Texas At Arlington: Administrative Office
1 mile

In the U.S. K is for...

...and the Economic implications are considerable



Source: EIA, 2012

Unconventional Reservoirs

Economic Implications

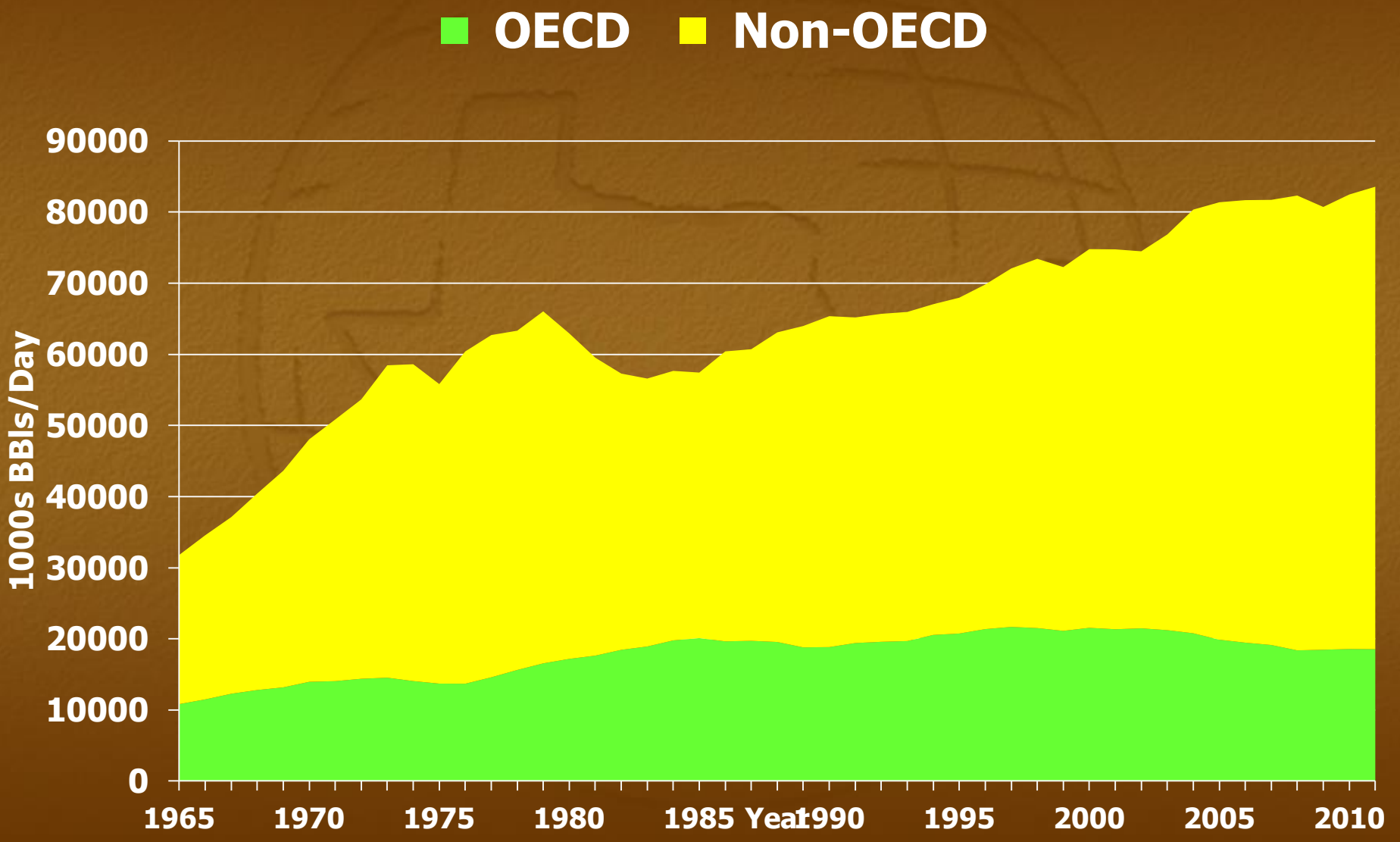
- Balance of Trade
  - ✓ Exports: Natural gas, liquids, products
  - ✓ Imports: Oil
- Regulation and Planning
  - ✓ Infrastructure
  - ✓ Resources
  - ✓ Permitting
- Emissions
- Energy Security

Outline

- A Look Back
- The US Energy Mix
- **The Global Energy Mix**
- Forward Steps

Tinker, 2013

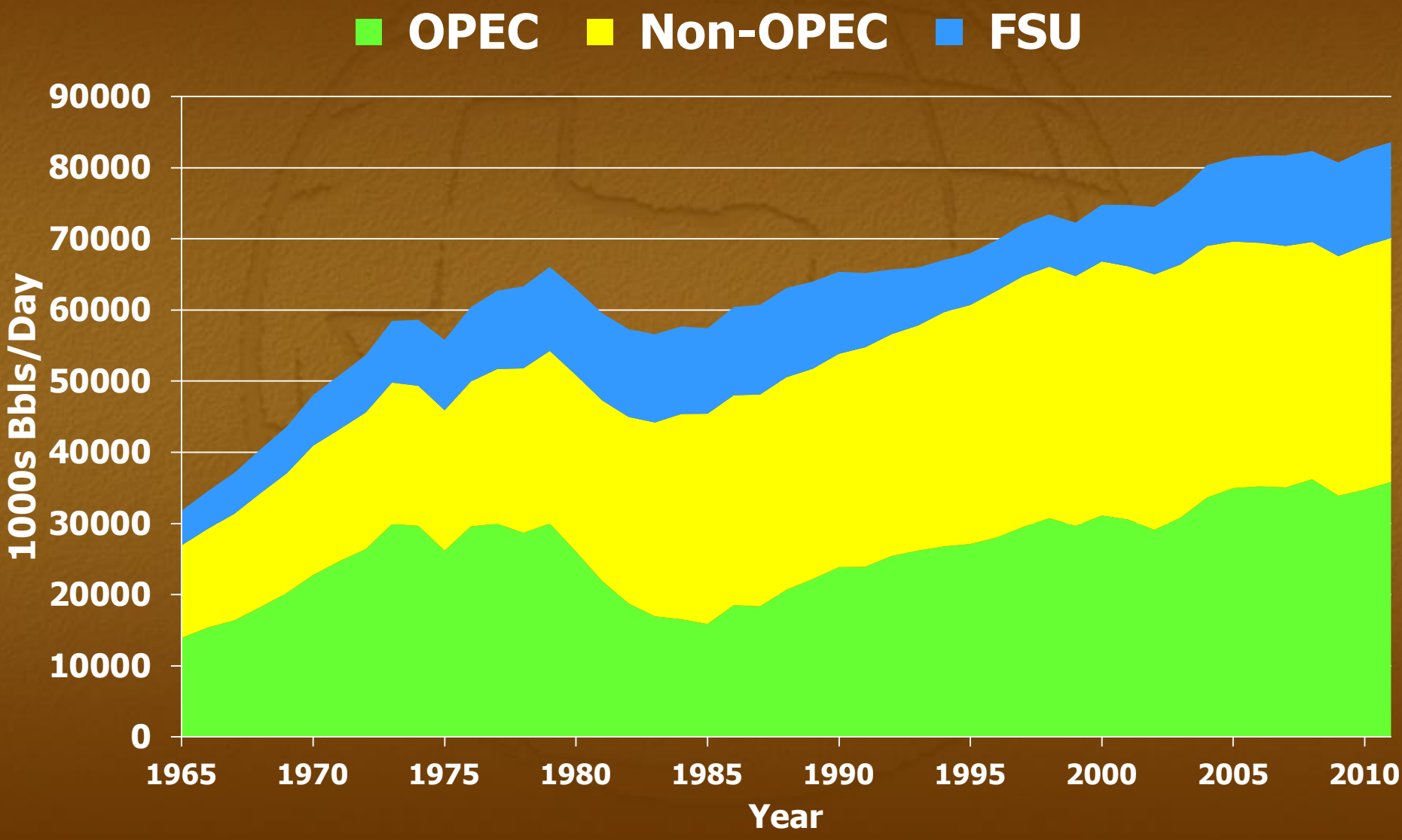
Global Oil Production



Source: BP Statistical Review 2012

Tinker, 2013

Global Oil Production



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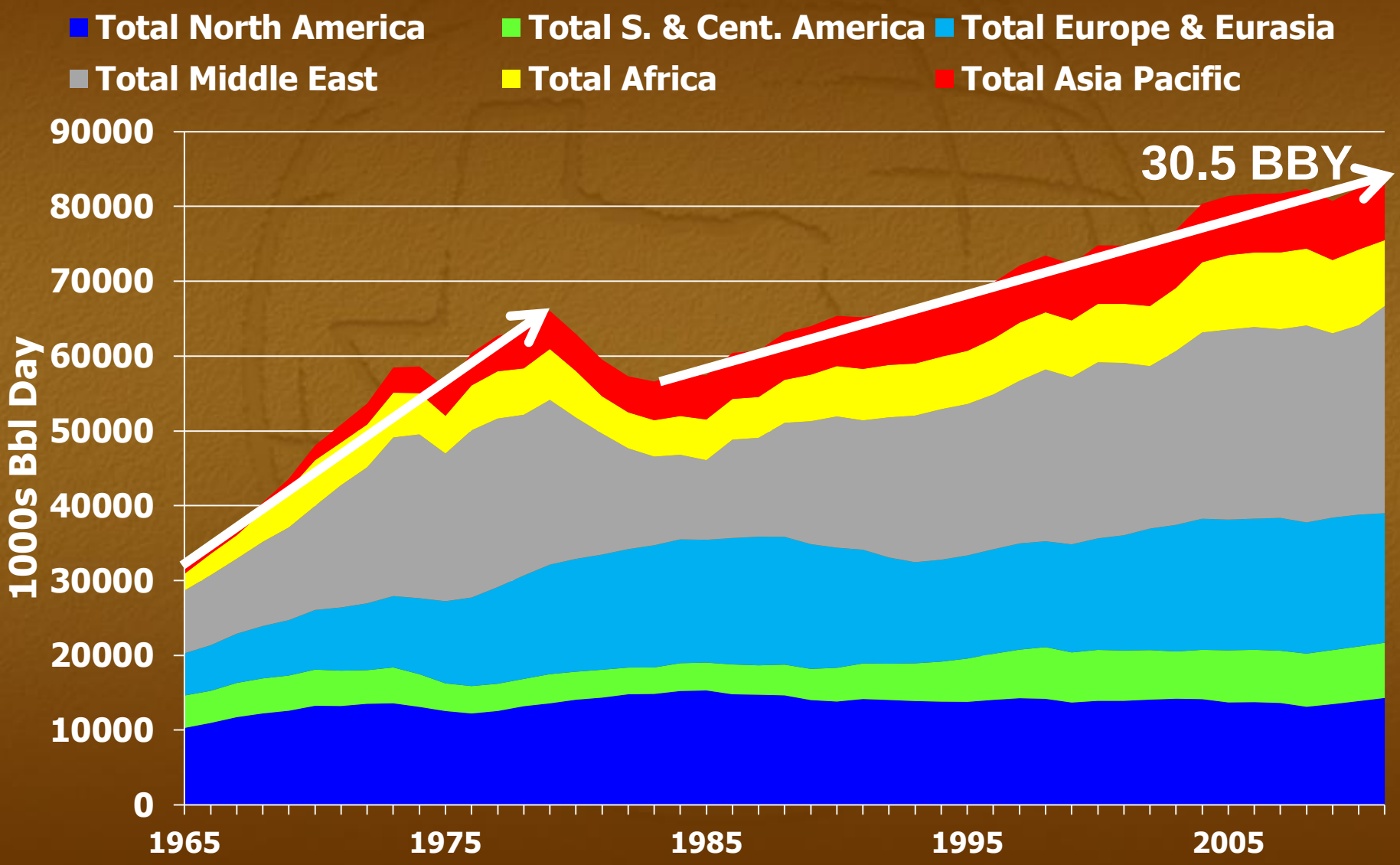
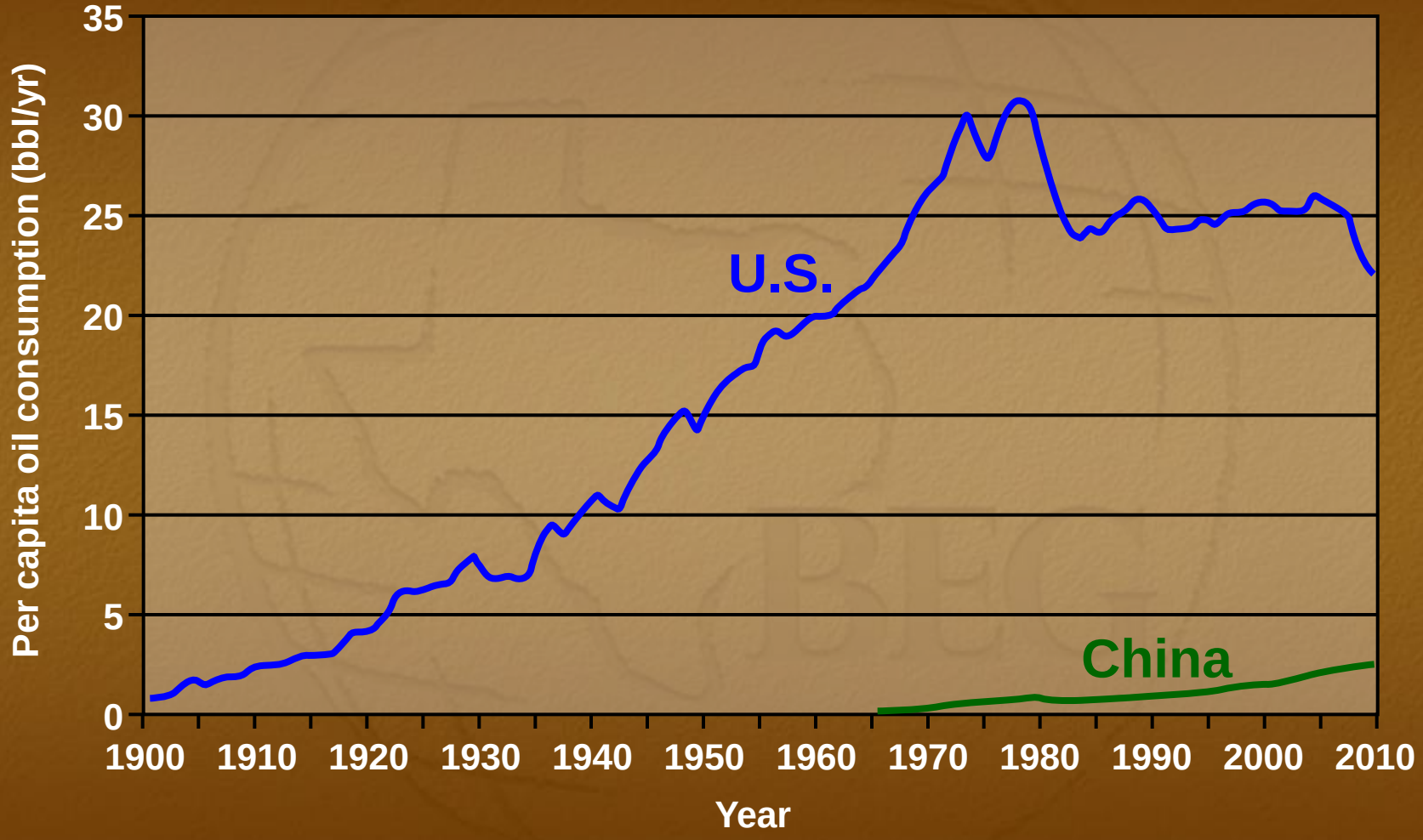


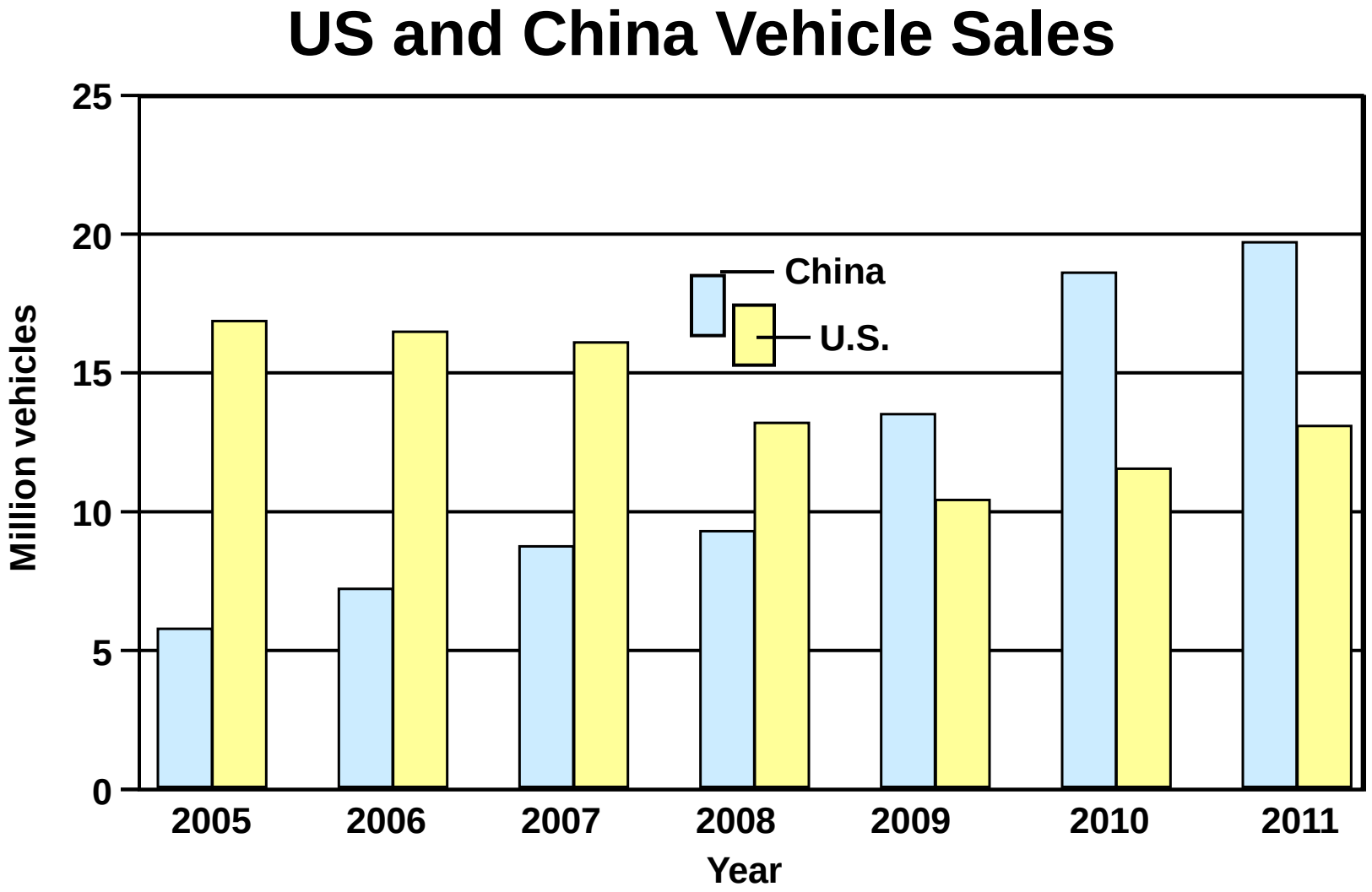
Source: BP Statistical Review 2012

Oil Consumption



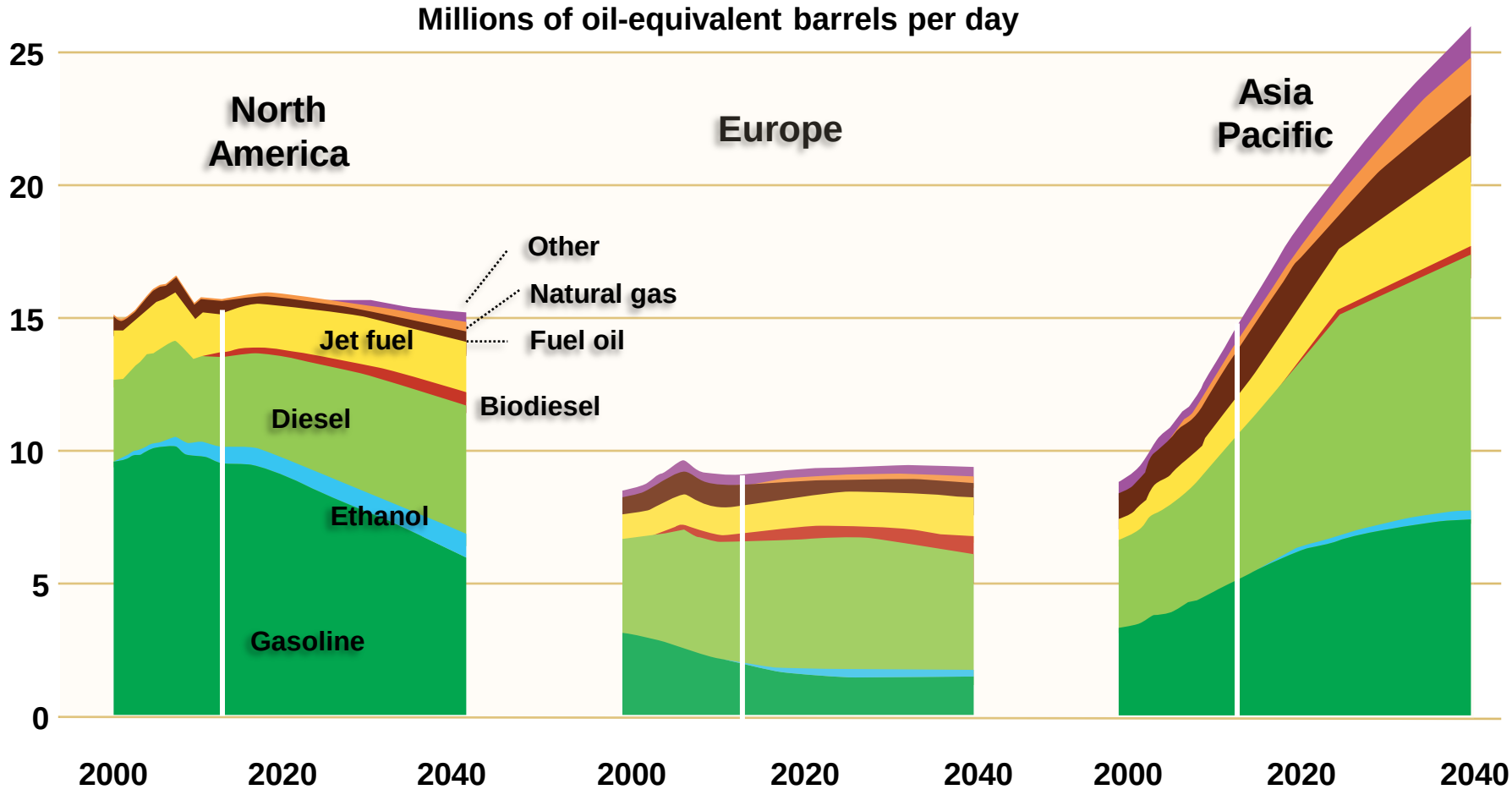
BP Statistical Review of World Energy, CIA World Factbook, Census Bureaus, Marc Faber Limited, RJ Estimates
From Raymond James and Associates, Inc., August 2, 2010

Oil Consumption



U.S. Bureau of Transportation Statistics, RJ Estimates, China Association of Automobile Manufacturers
From Raymond James and Associates, Inc., August 2, 2010

Oil Consumption

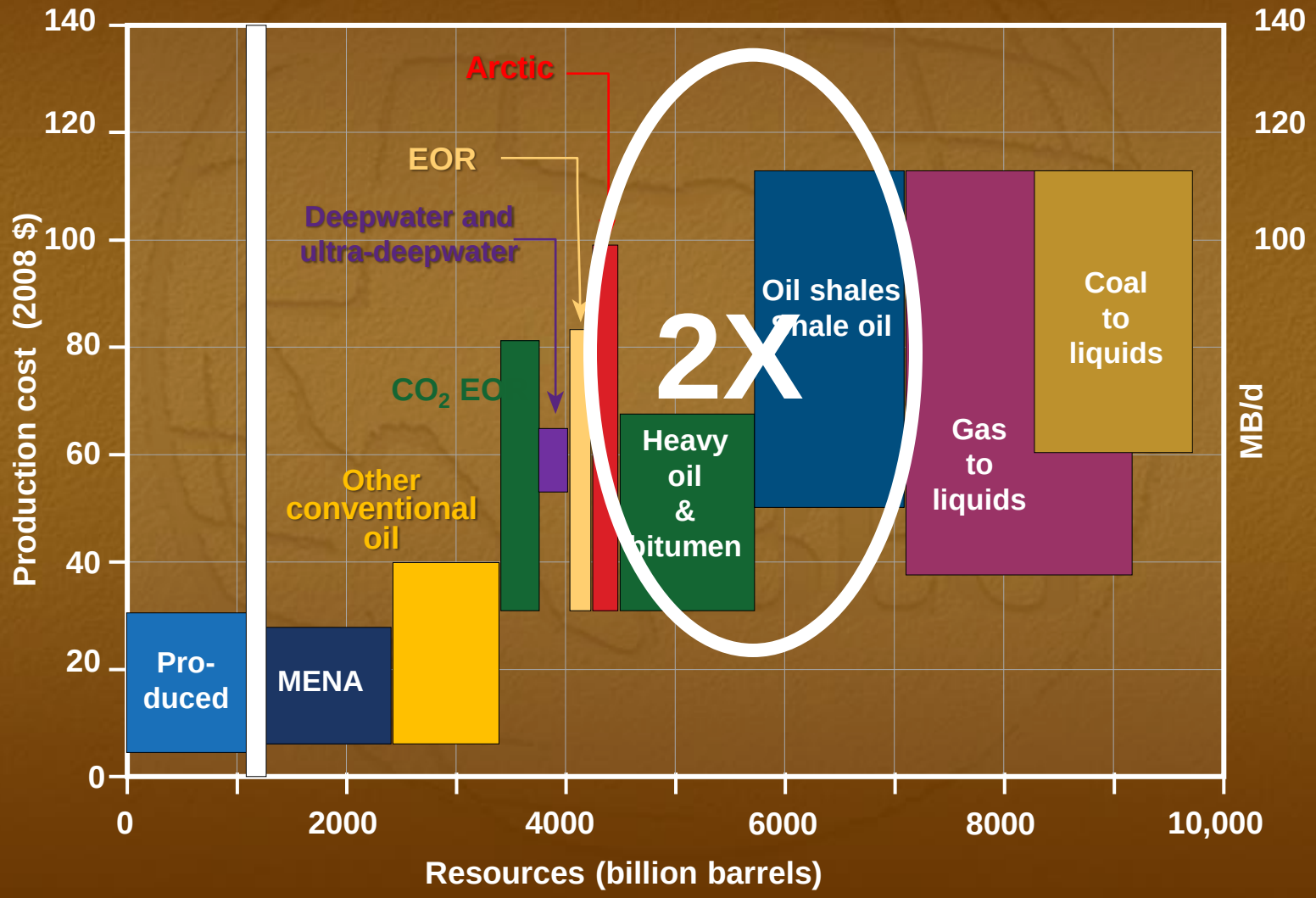


ExxonMobil Corporation, 2013 The Outlook for Energy: A View to 2040, page 20.

Tinker, 2013

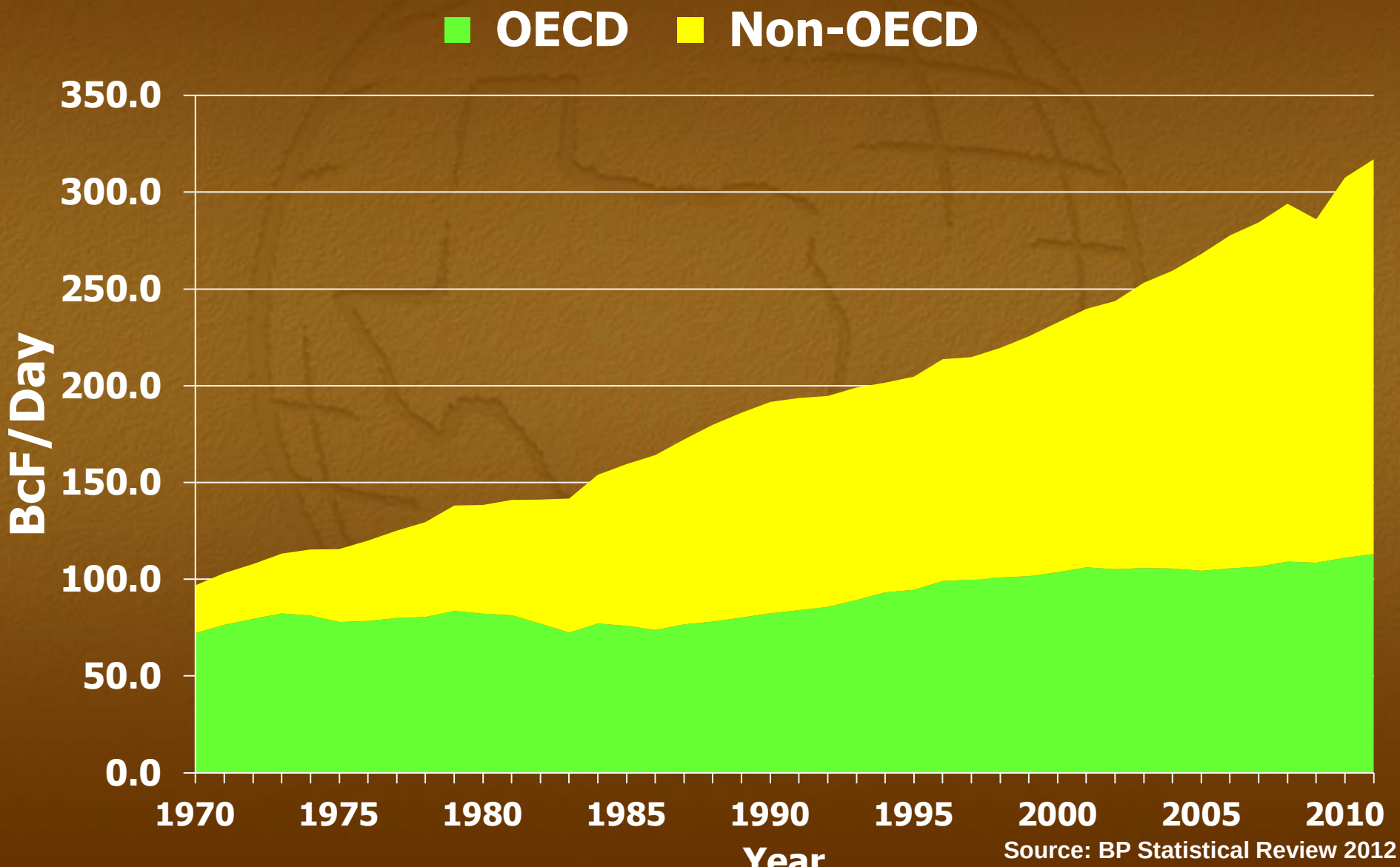
Long-Term Oil Supply

Resources and Production



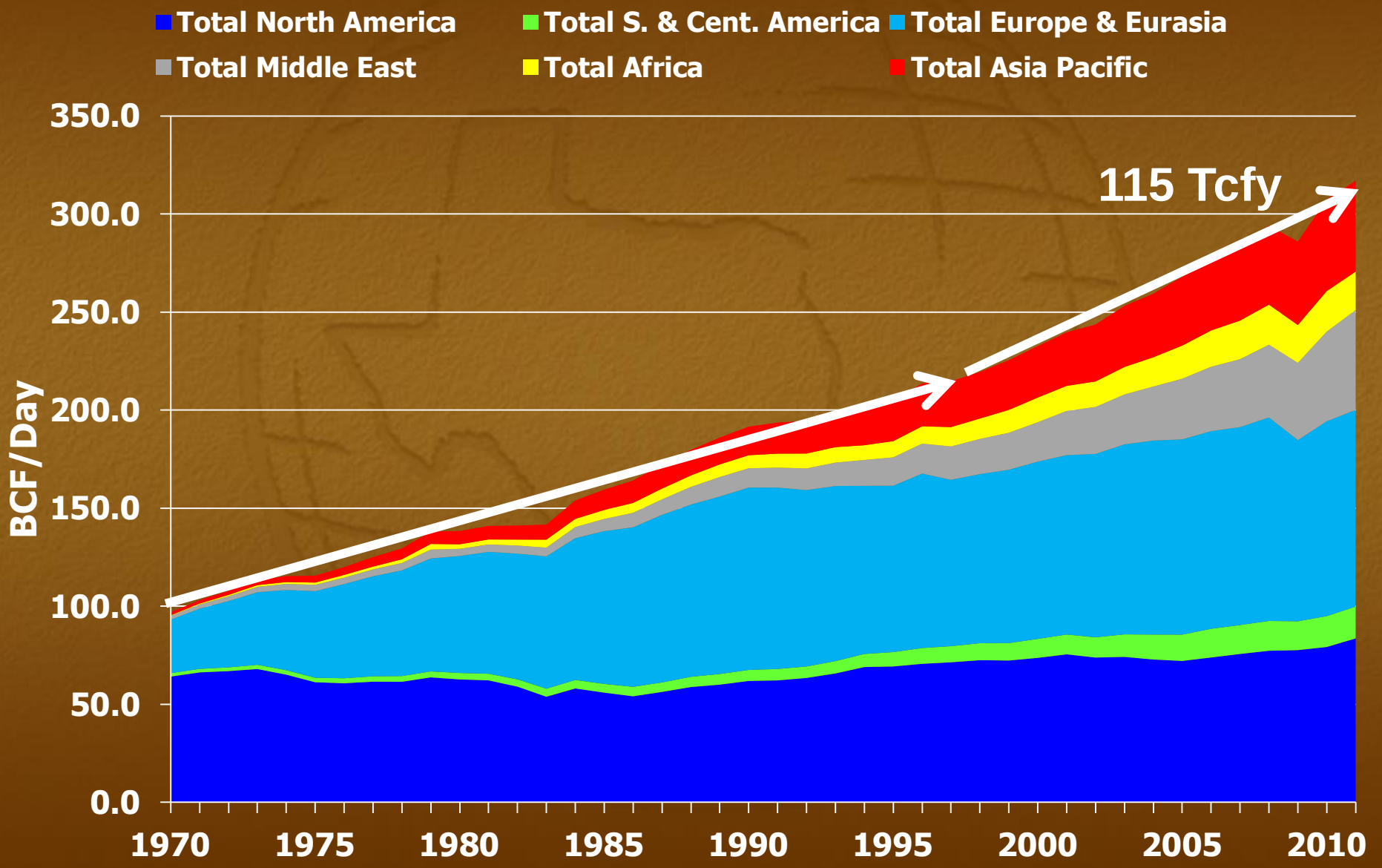
Source: IEA World Energy Outlook (2009)

Global Natural Gas Production



Source: BP Statistical Review 2012

Global Natural Gas Production

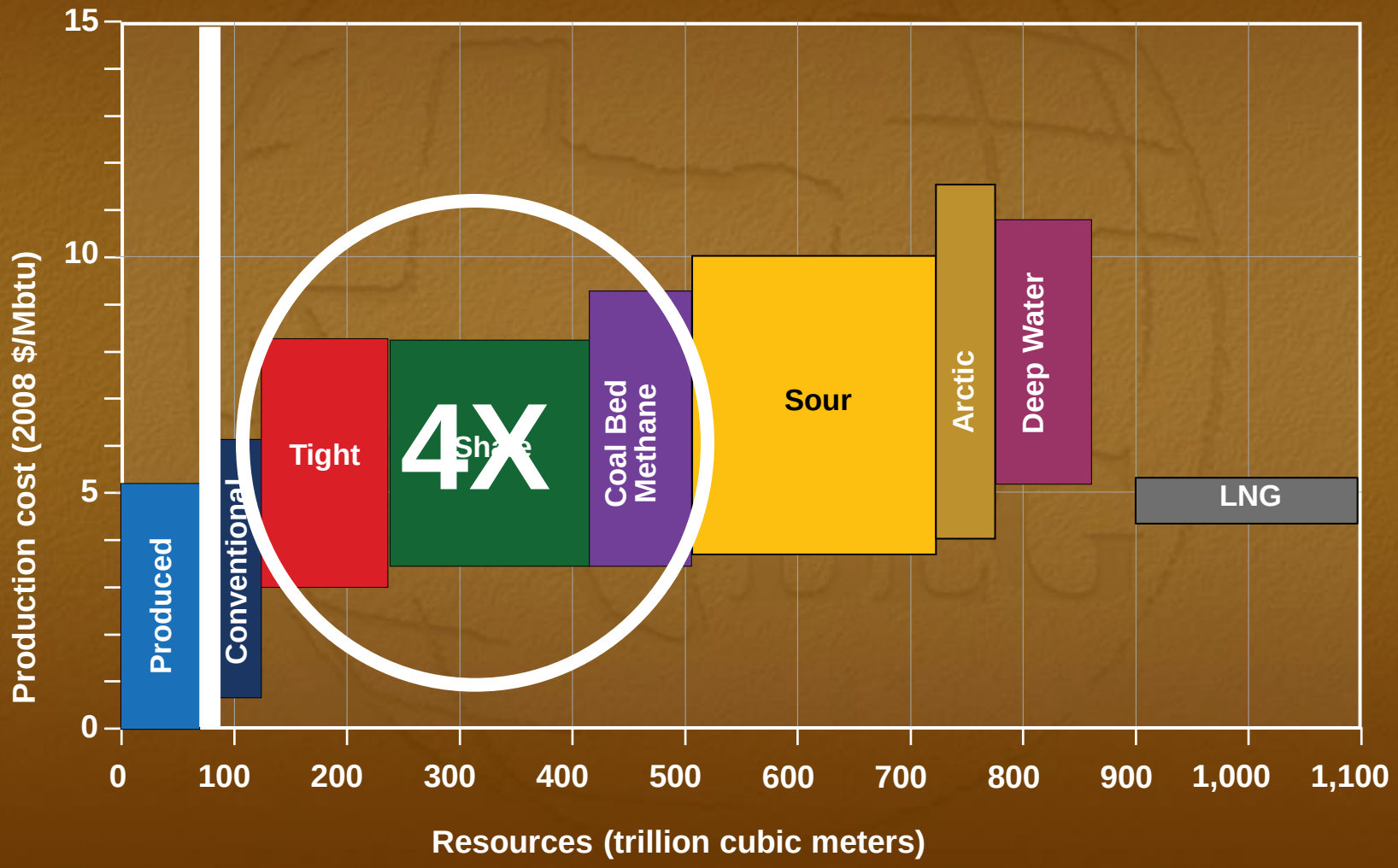


Source: BP Statistical Review 2012

Tinker, 2013

Natural Gas Supply

Resources and Cost



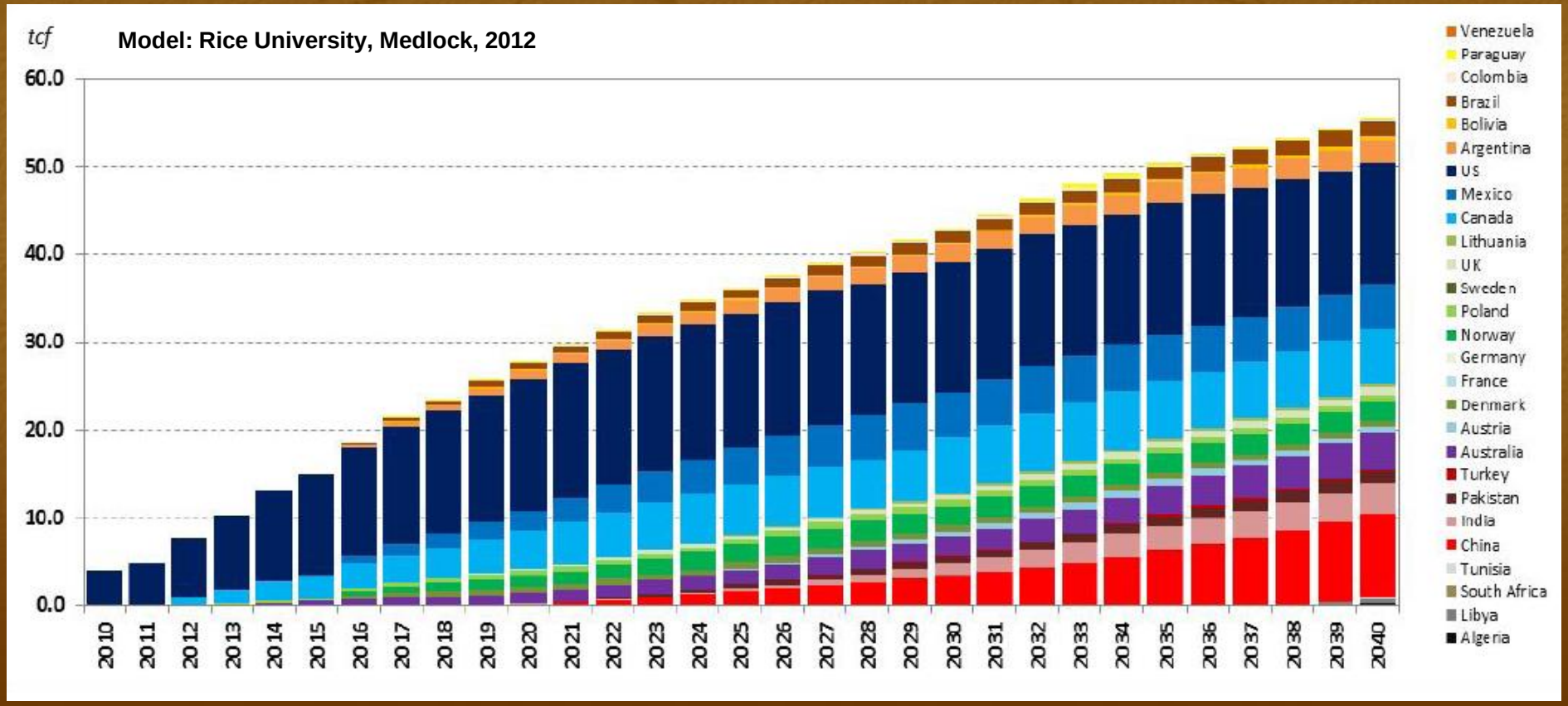
Source: IEA World Energy Outlook (2009)

QAe980

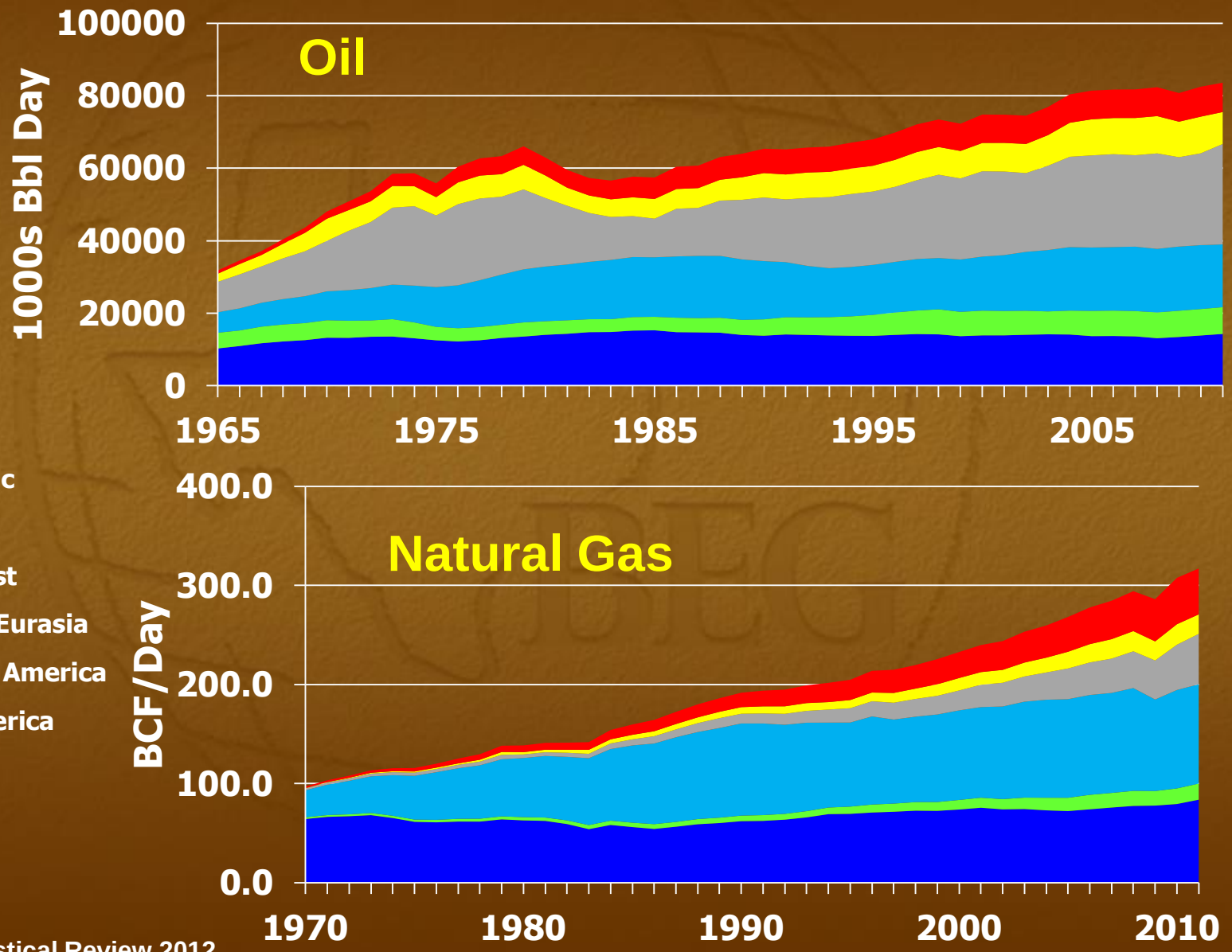
Tinker, 2013

Natural Gas Supply

Resources and Cost



Global Comparison



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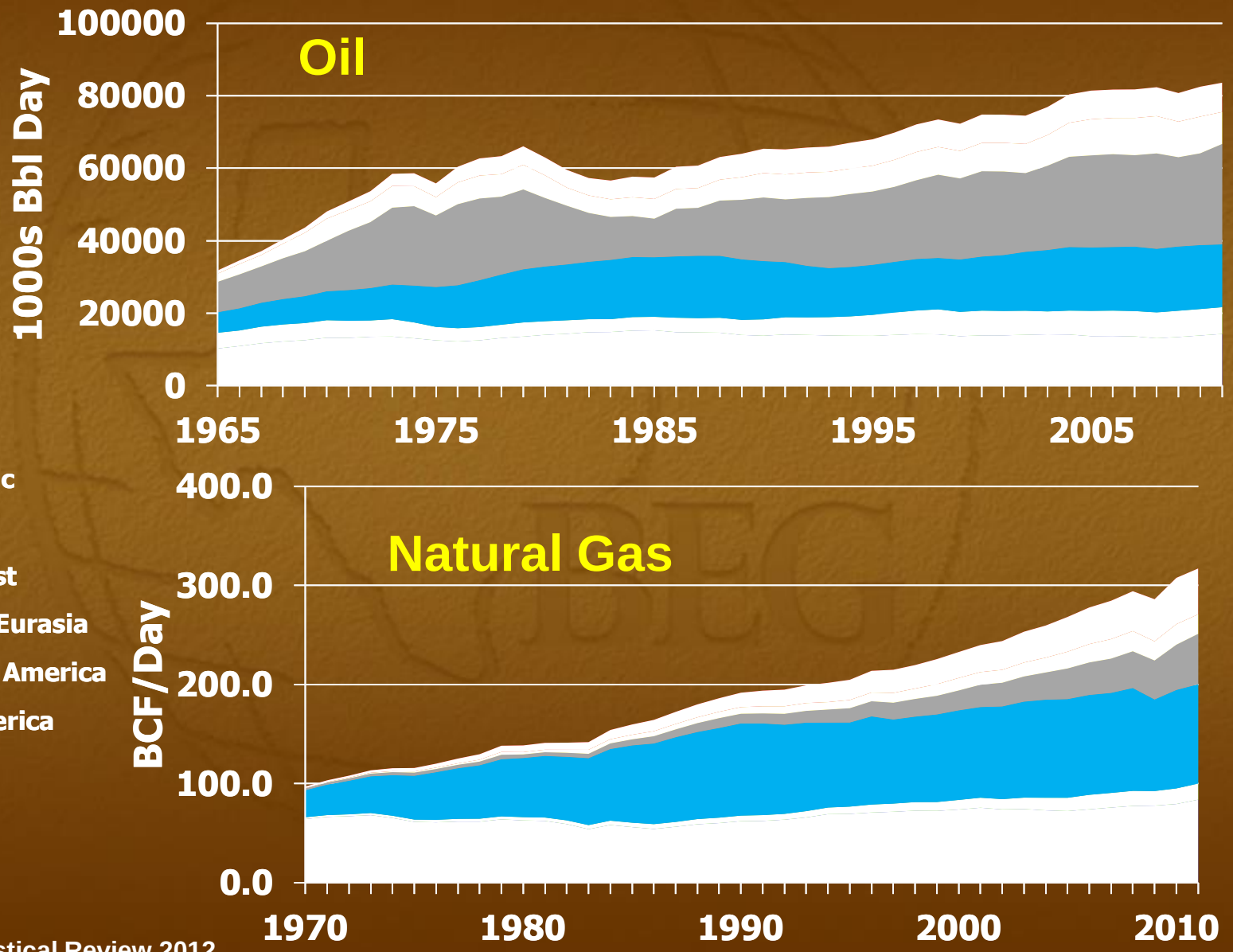

Source: BP Statistical Review 2012

Global Shale Oil and Gas Basins

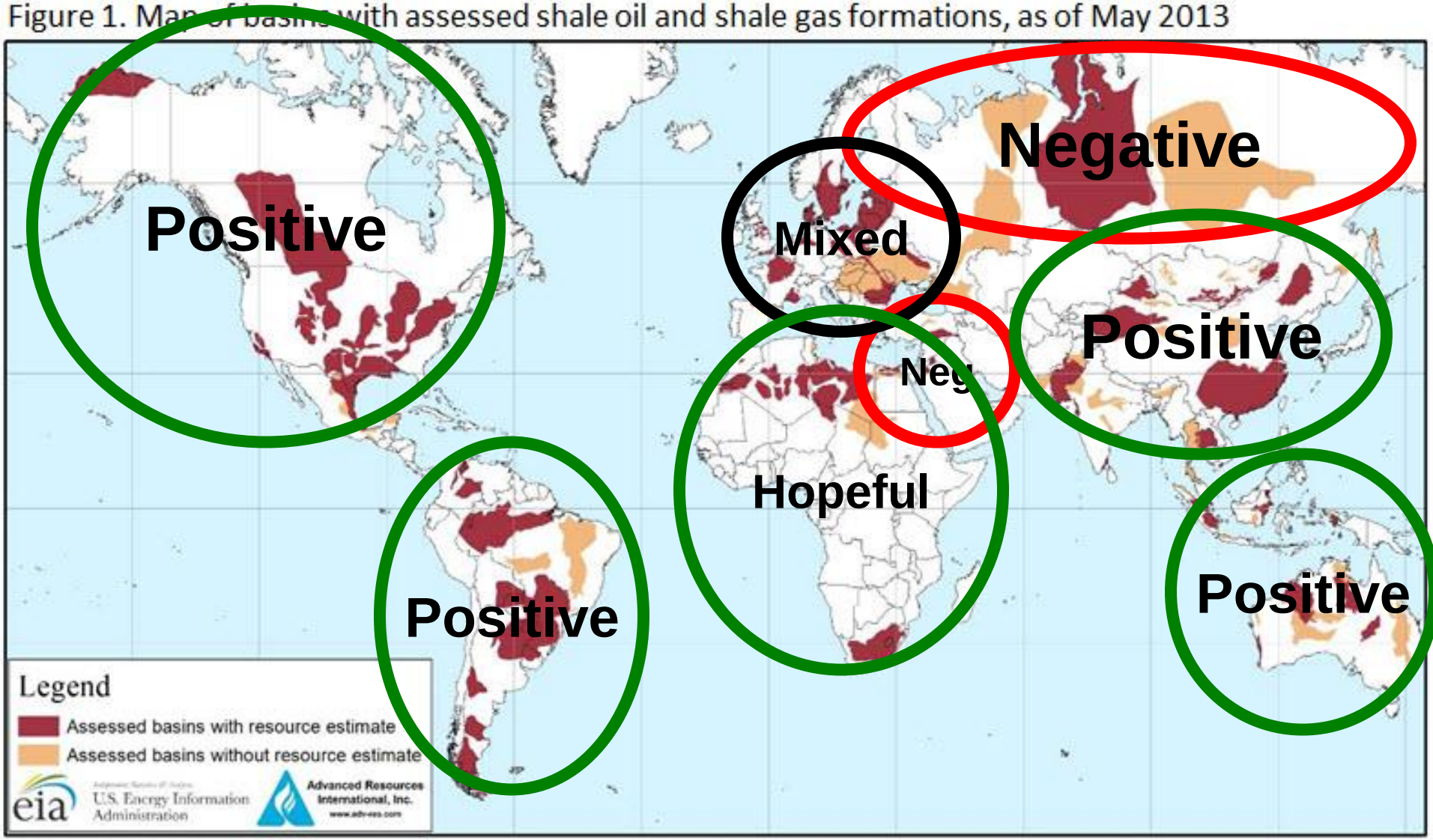

Figure 1. Map of basins with assessed shale oil and shale gas formations, as of May 2013

Source: United States basins from U.S. Energy Information Administration and United States Geological Survey; other basins from ARI based on data from various published studies.

Tinker, 2013

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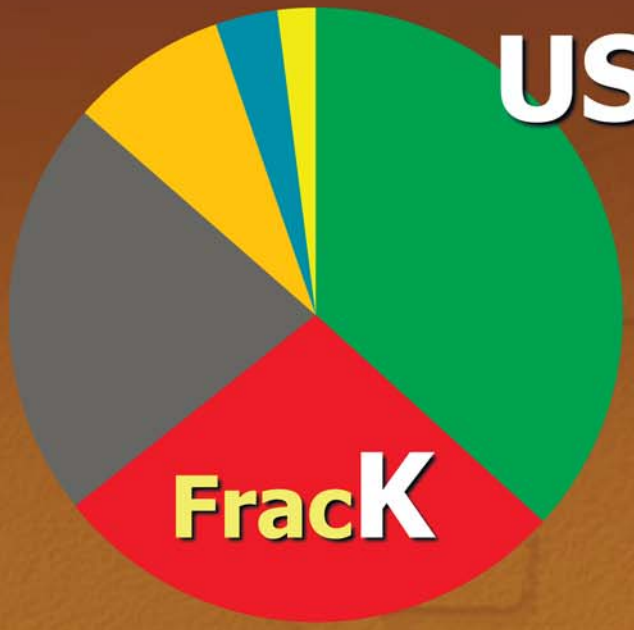
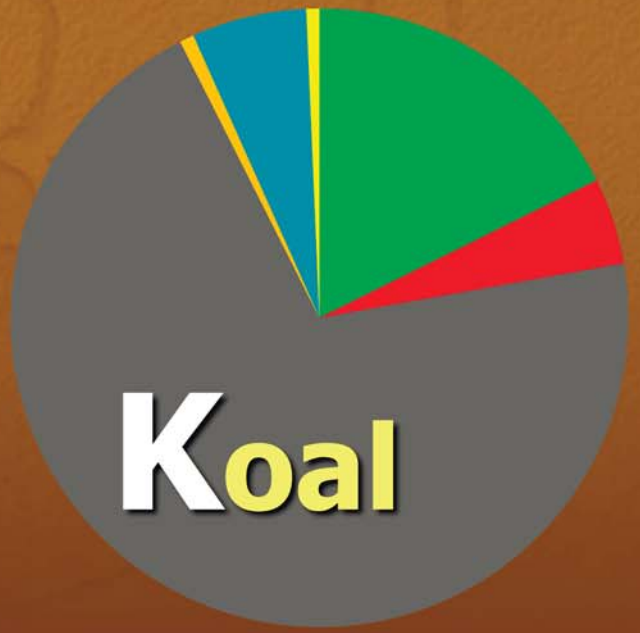
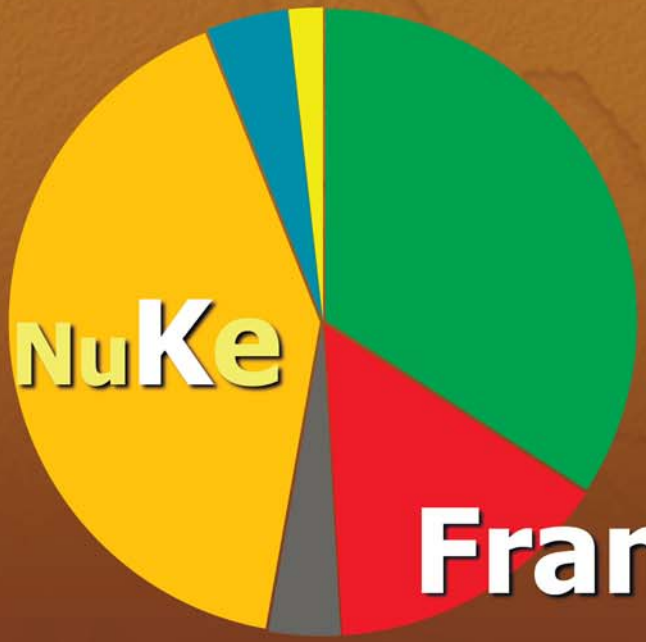
Tinker, 2013

"K" is for…



- Oil
- Natural gas
- Coal
- Nuclear energy
- Hydroelectricity
- Renewables





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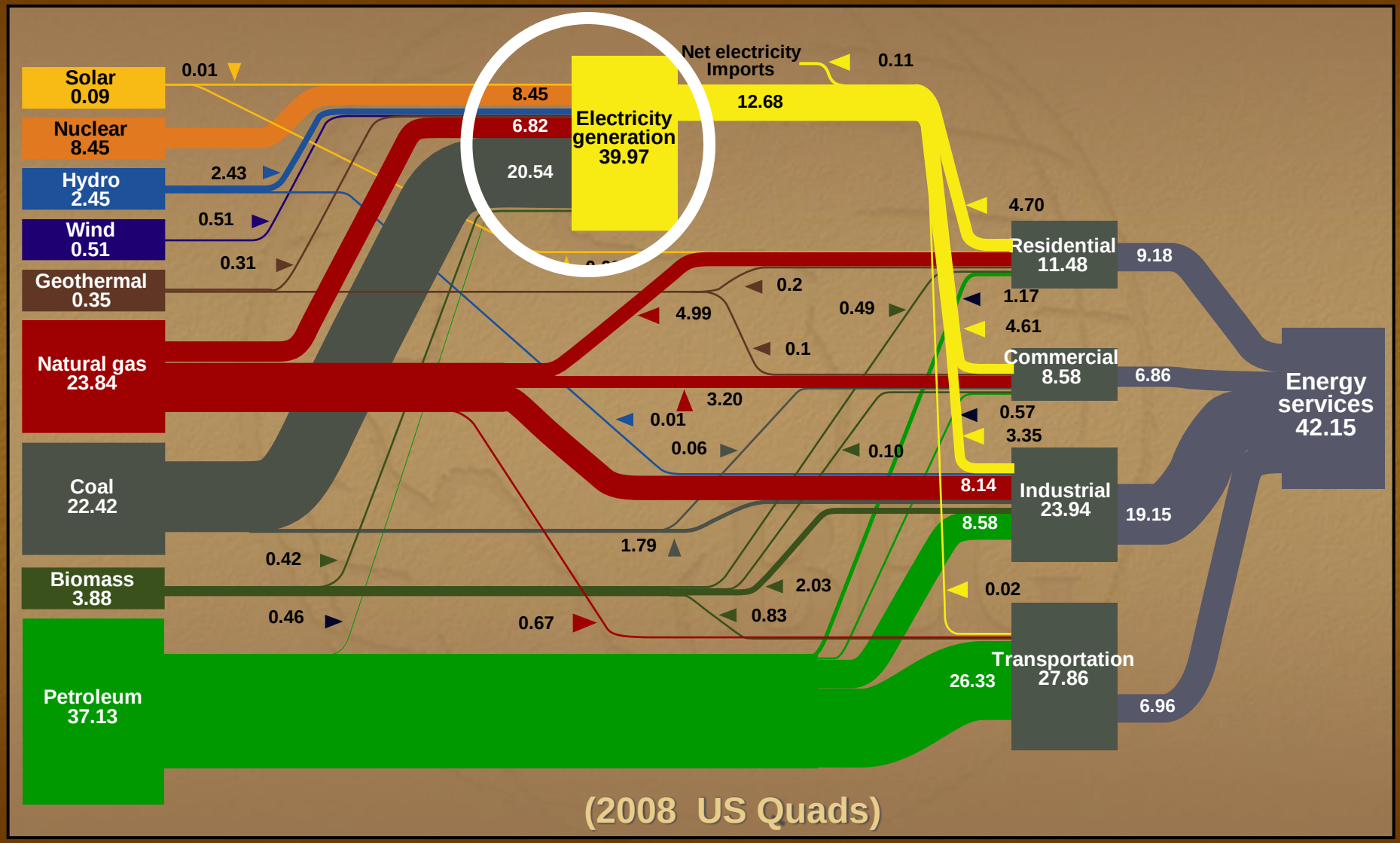
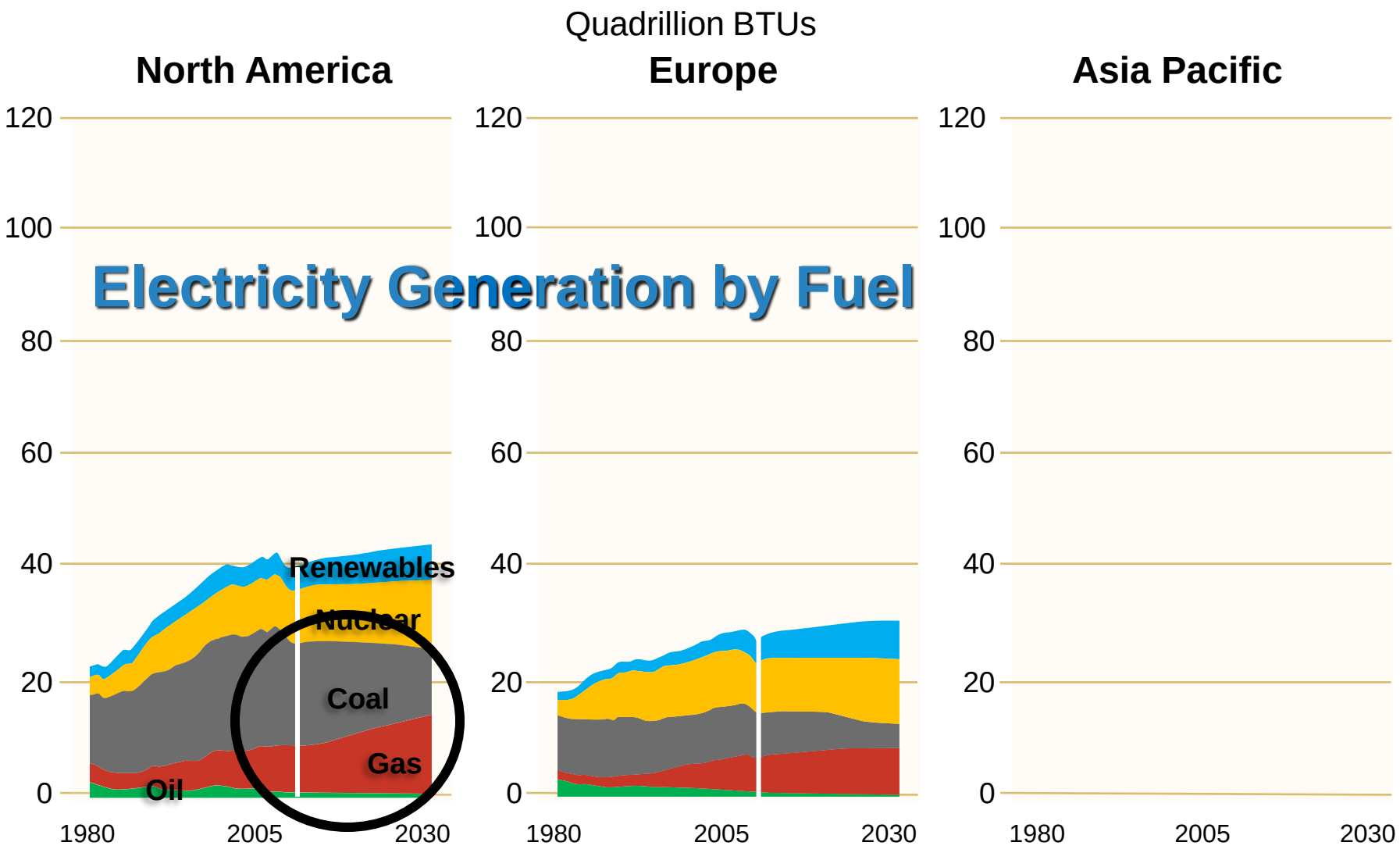
Energy Flows



Source: Lawrence Livermore National Laboratory and U.S. DOE based on Annual Energy Review, 2008 (EIA, 2009)
From National Academies Press, *America's Energy Future*, 2009

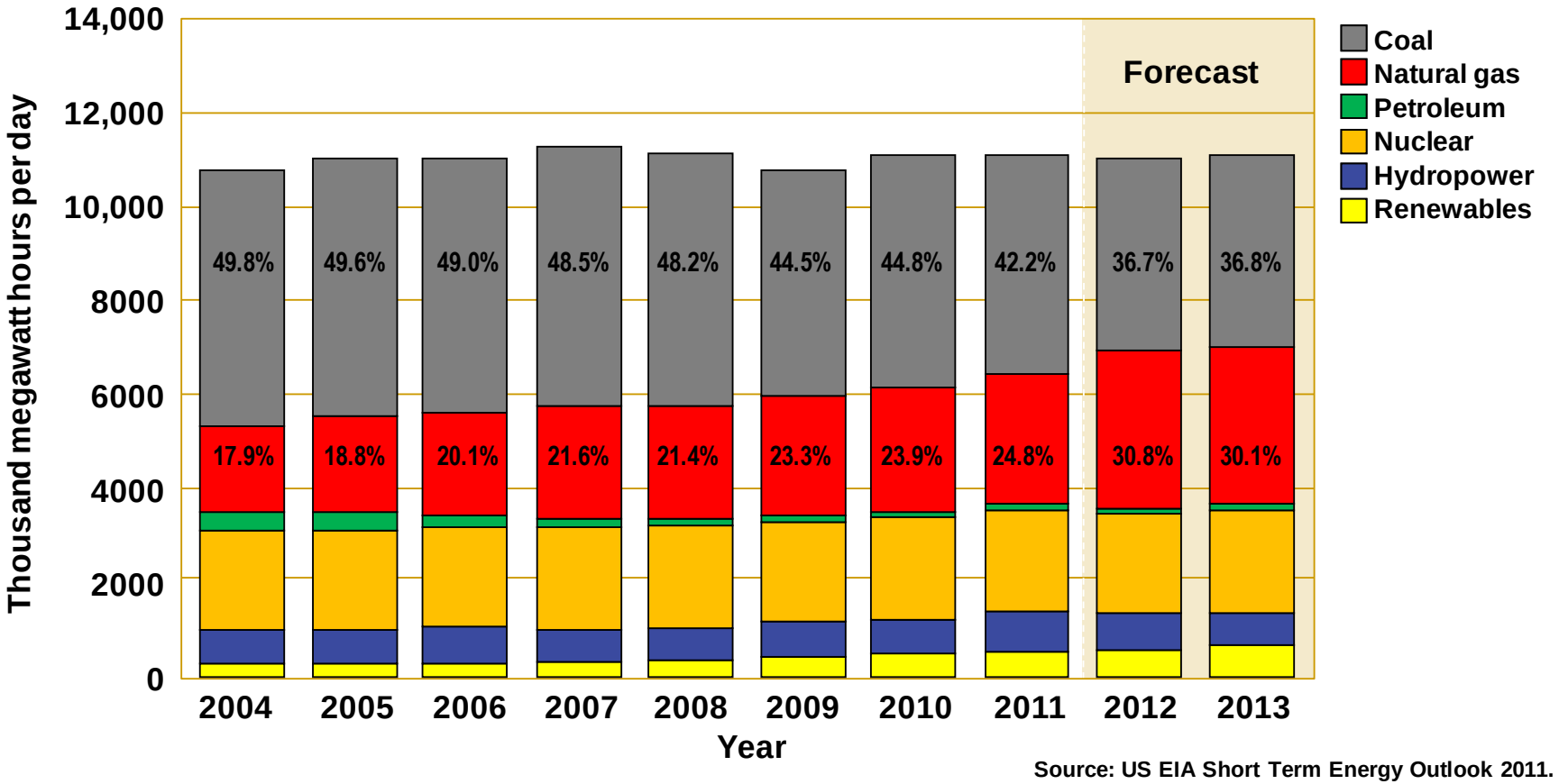
Energy Flows



ExxonMobil Corporation, 2010, The outlook for energy: a view to 2030: ExxonMobil report, 53 p.

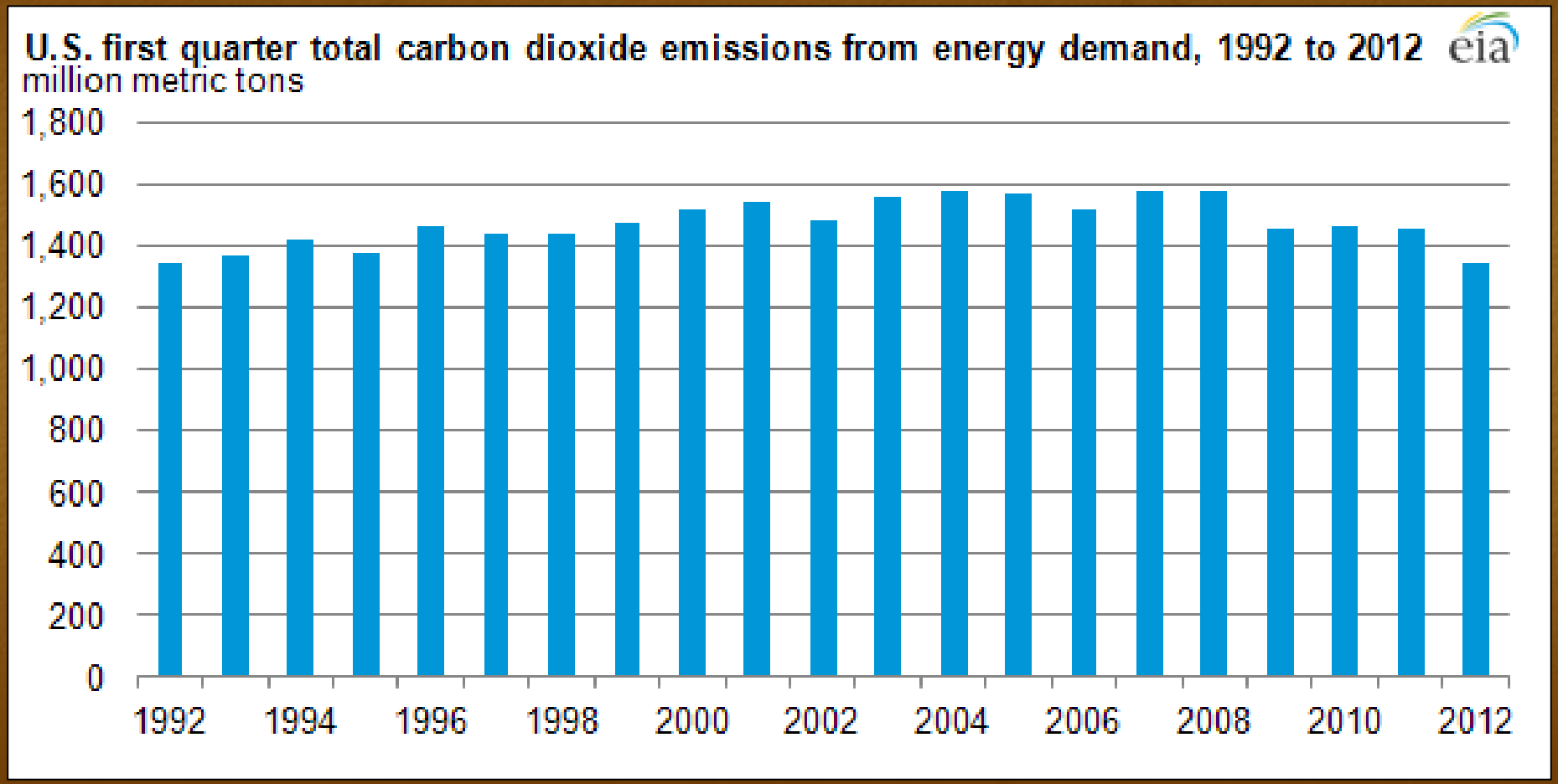
Energy Flows

US Electricity Generation by Fuel, All Sectors

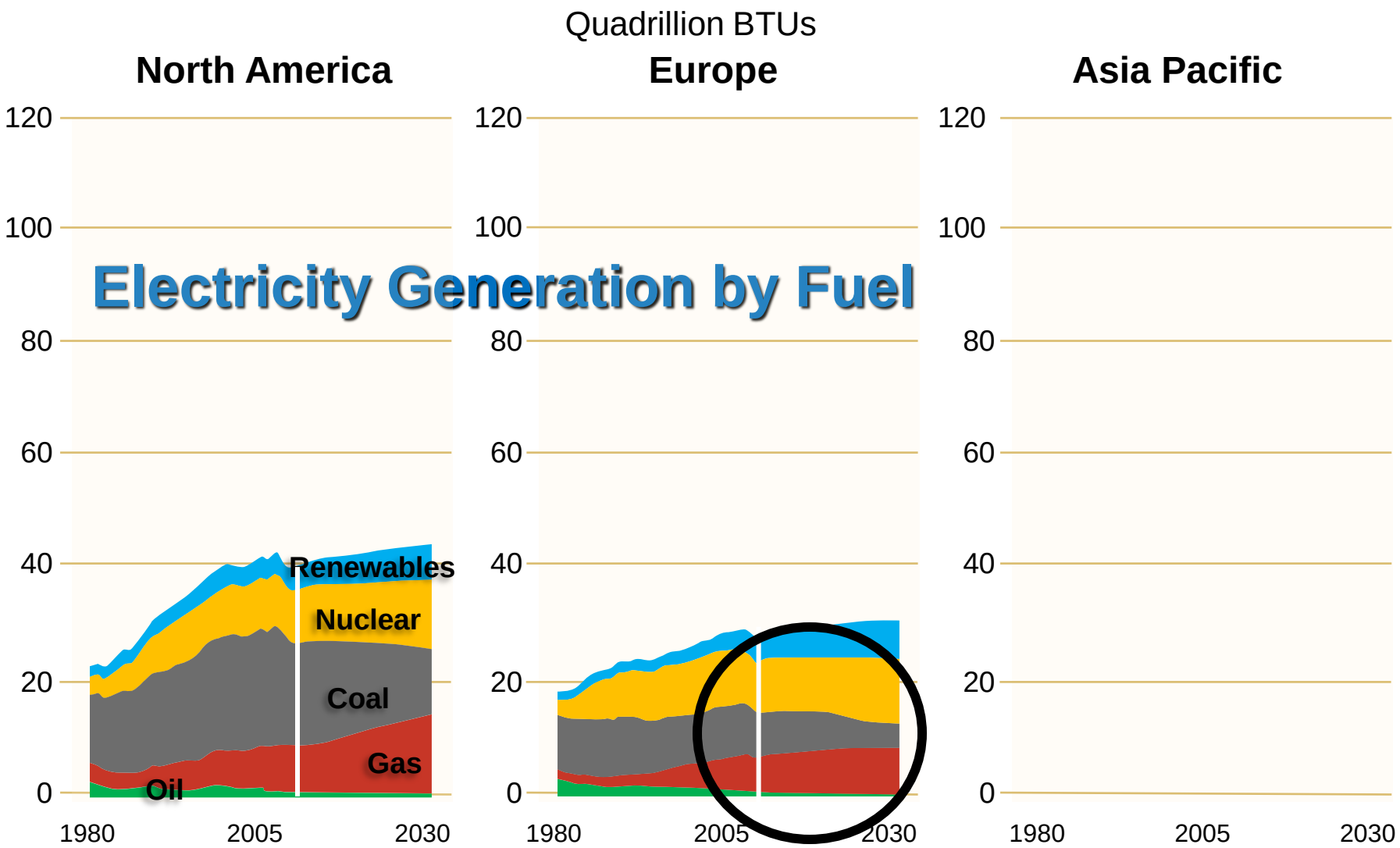


Source: US EIA Short Term Energy Outlook 2011.

Energy Flows



Energy Flows



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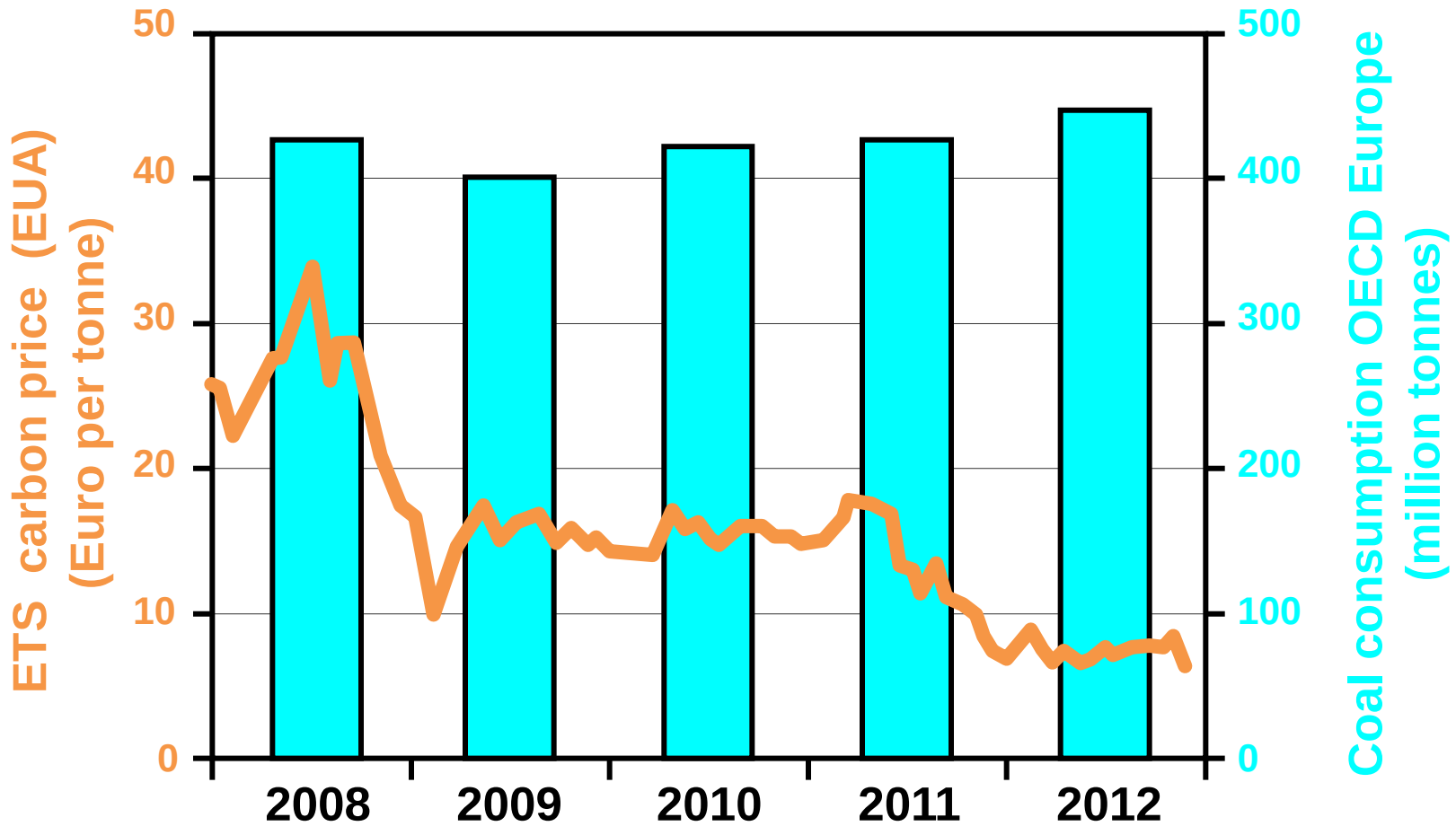
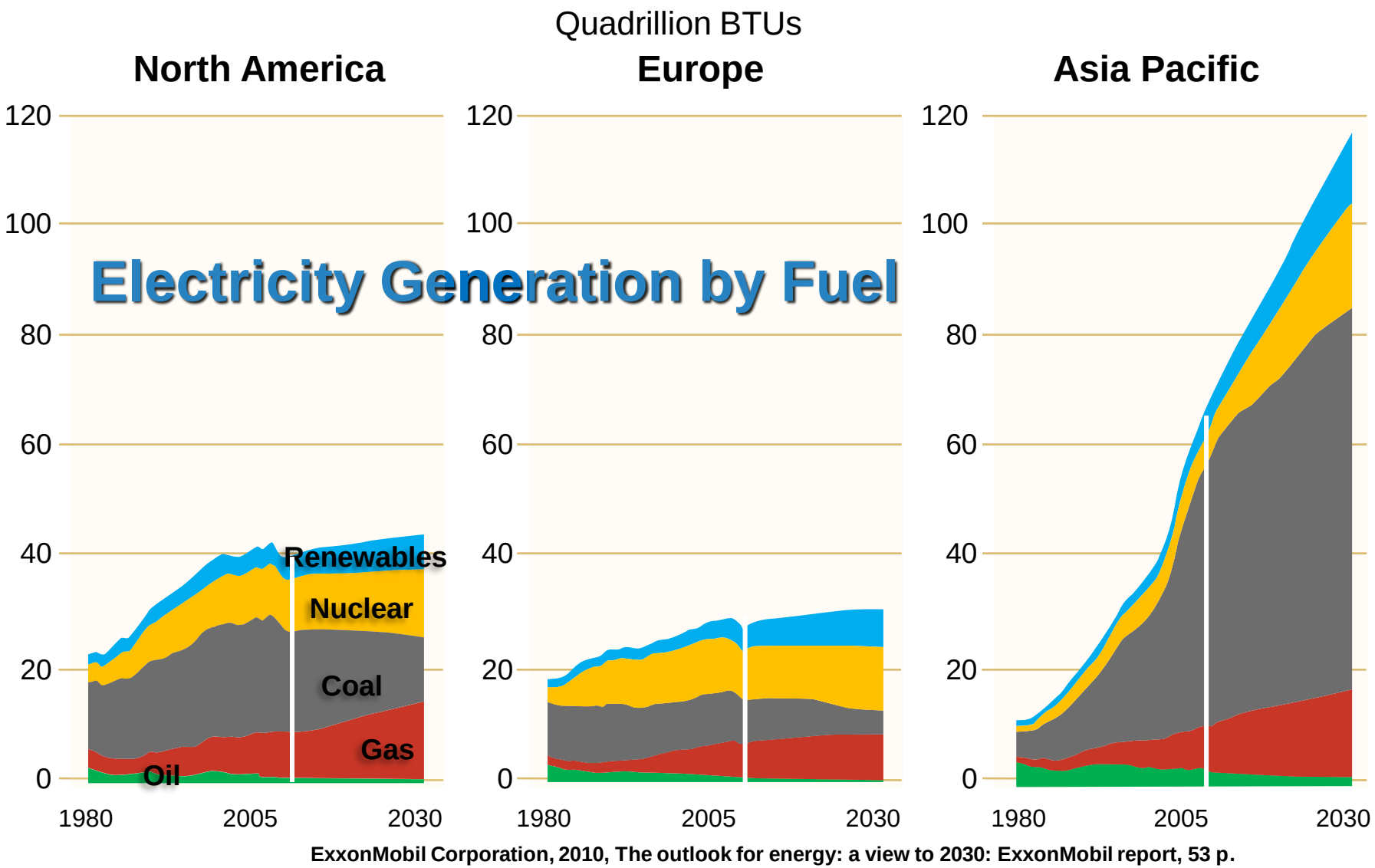


Thompson Reuters, IEA

Energy Flows



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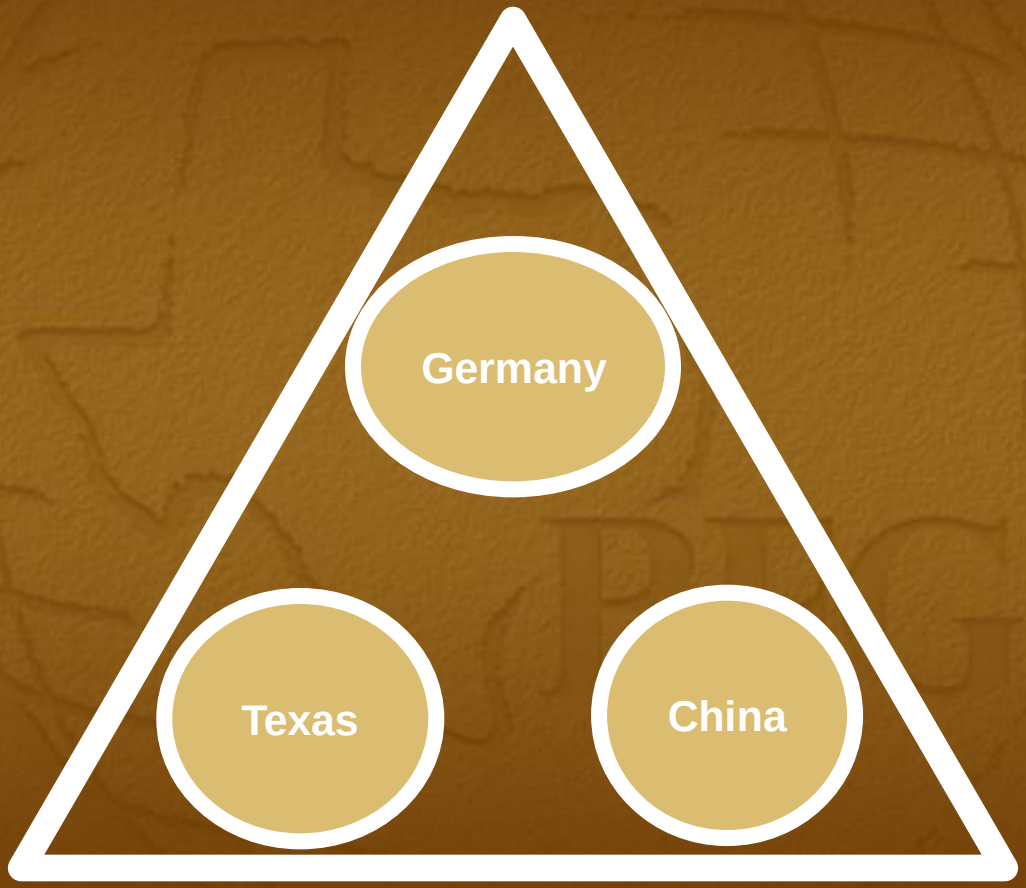
Tinker, 2013

The 3E Waltz



Tinker, 2013

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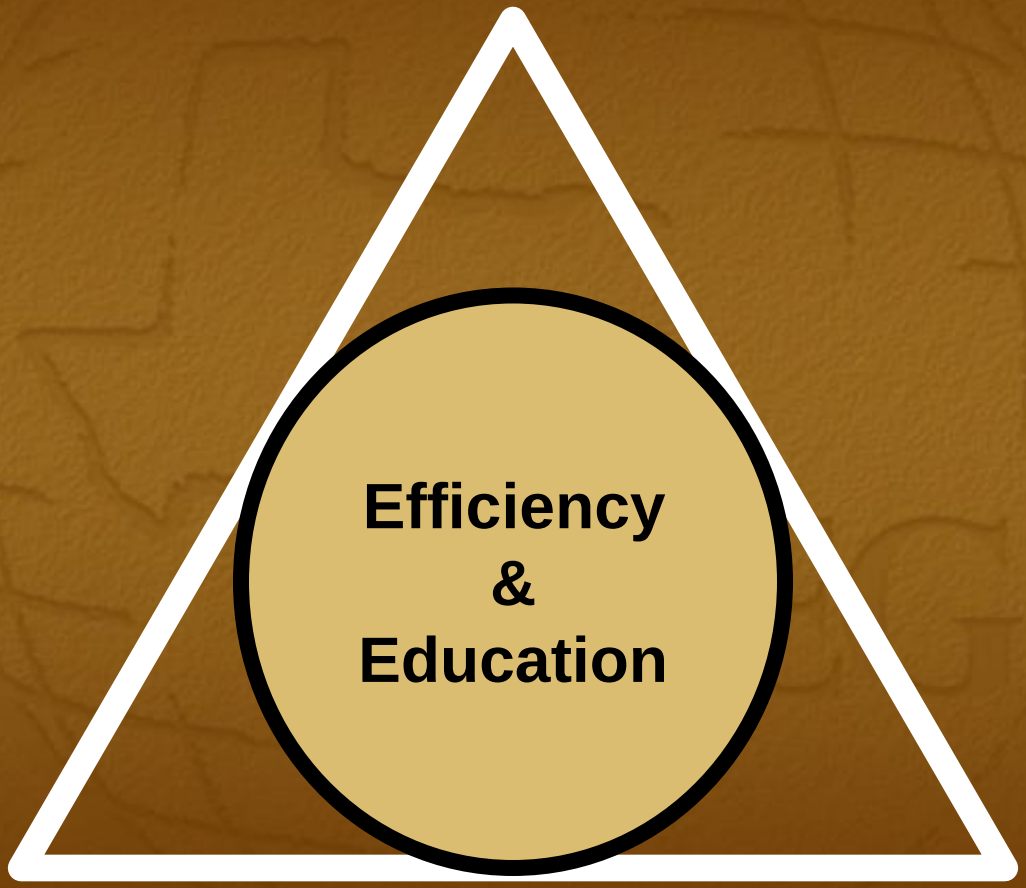
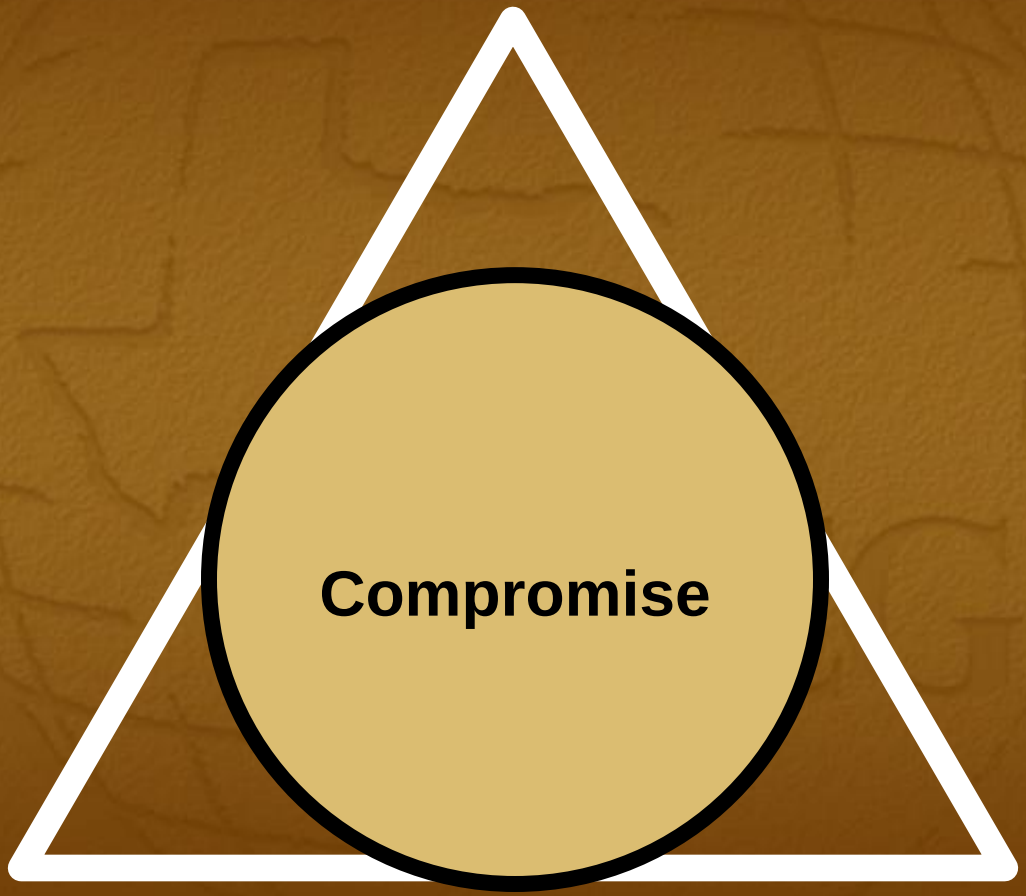


Tinker, 2013

Leaving our Corners

Government



Academia/NGO

Industry

Roles for the Independent

- Evaluate low-cost, targeted operations in existing shale gas plays
- Consider shallow-water offshore lease acquisition opportunities
- Pioneer development of other organic-rich, tight rock plays (e.g. limestone)
- Develop international opportunities in lower-political risk countries
- Be the bridge between local, state and federal regulators and policy makers

Larger Trends

- The scale of energy demand is enormous
- Oil and gas are a part of the future energy mix and shale will play a growing role
- Above-ground challenges are real and rigorous operational practices are key
- Energy security—affordable, available, reliable, sustainable—will drive the future energy mix